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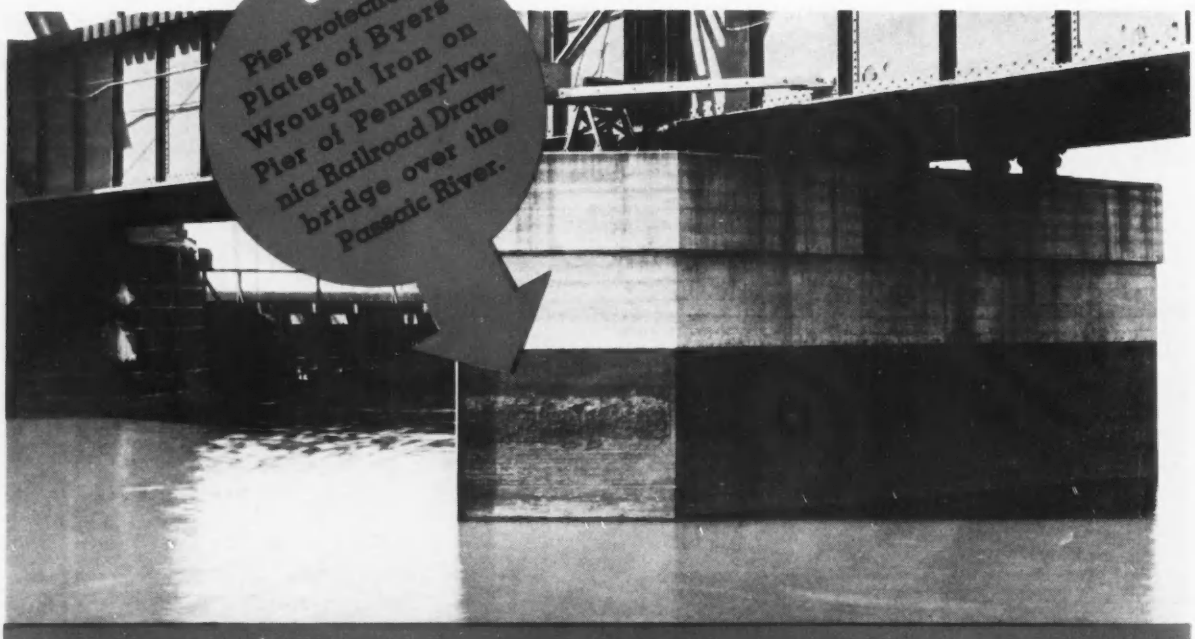

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A MOMENT WITH THE PUBLISHERS

NEW BLOOD for the Profession

WITH the passing of another commencement season the profession has welcomed to its ranks a new corps of young engineers. For a few years just passed the graduates have had a pretty thin time of it to find a job; today most of the schools report substantial improvement in that respect.

But it is worth while to remember that, although a job is for each a vital matter of primary concern, the engineers can justify their fellowship in a profession only as they look beyond their own jobs and consider the situation of the profession as a whole. The essence of any profession is an implied obligation to each other and to the community aside from the material considerations of the day's work.

In this connection, commencement time always rouses memories of the old style commencement speaker, now happily almost extinct. He seemed to fear that unless the graduates were properly cracked down at the outset they would become insupportably cocky and worthless. More often than not the youngsters were told that they were "not yet engineers" and grave doubts were cast on their ability ever to become engineers.

Probably this oratorical hazing originated in the days when college training for engineers was a new-fangled idea and when the commencement speaker was an "eminent engineer" who had been graduated from "the college of hard knocks," intensely proud of his Alma Mater and proportionately intolerant of any other. But with all due respect to those stalwarts who achieved distinction in the pioneer days of engineering practice, that particular form of commencement address is obsolete. Today the college trained engineer is the rule; the man without a technical education has but a slim chance to make even first base.

THE observation of this writer is that most engineering graduates are not complacent or cocky; they are more likely to be suffering from an inferiority complex. They do not need to be cracked down; they need more than anything else to be encouraged and inspired to take pride in the place they must occupy and the part they must play in the work of our very complicated world.

This comment is not born of any excessive solicitude for the feelings of the graduates. It is directed chiefly to the well-being of the profession itself. If the engineers ever are going to establish the standing and influence of their profession they must begin by building up the self-respect of their novices, not by tearing it down. We cannot build up the strength of a profession by having our recruits regard themselves as hewers of wood and drawers of water. Quite to the contrary, we must inculcate in them a conviction that they are of a select company, trained for a mission that involves obligations beyond those of other callings.

Of course the fledgling engineer has a lot to learn; who has not? Of course he is lacking the mature judgment of the more experienced; but aren't we all? So far as concerns his professional status, however, he has arrived; he should be so acclaimed and established by his professional brethren in his own sight and in that of the world.

TODAY the profession has greater need of its full strength than ever before. Somewhat groggy under the impact of the depression, many of our people are easy prey to the delusion that somehow the engineer and his power-driven machines are responsible for much of our economic distress. From time to time this page has discussed that notion; this is no time to review it. On the profession as a whole rests the responsibility for attacking such error and for building up a more adequate understanding of the engineer's indispensable contribution to social progress. To do that we need a strong profession inspired throughout by a sense of its mission and responsibility.

If and when the individual demonstrates his inability or unwillingness to conform to such a standard it will be time to leave him free to seek new affiliations. But at the outset, the profession should do its best to hold fast all those who are graduated into its fellowship.

Willard Chevalier

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AT THE HOME OF THE WORLD'S CHAMPIONS, TOO

IT PAID TO FORGET THE OLD STUFF

● Just as those Detroit Tigers dashed through the American League to a World's Championship, the contractors who rebuilt Navin Field, Detroit, also played "head's up" ball.

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Prize Bridge—The Lorain Road viaduct in Cleveland has been included by the American Institute of Steel Construction among the three most beautiful bridges built last year. But the bridge is more than good looking; it displays design ingenuity and honesty in the use of materials that mark an advance in structural design. It will be described in the July 9 issue.

Traffic markers of Atlas White Portland Cement give this Tulsa, Oklahoma street four 10' center lanes, with an 8' lane on each side. Markers installed by the Standard Paving Co. of Tulsa, under supervision of State Highway Department. J. M. Klinglesmith, Resident Engineer; Chas. L. Wilson, State Highway Engineer.

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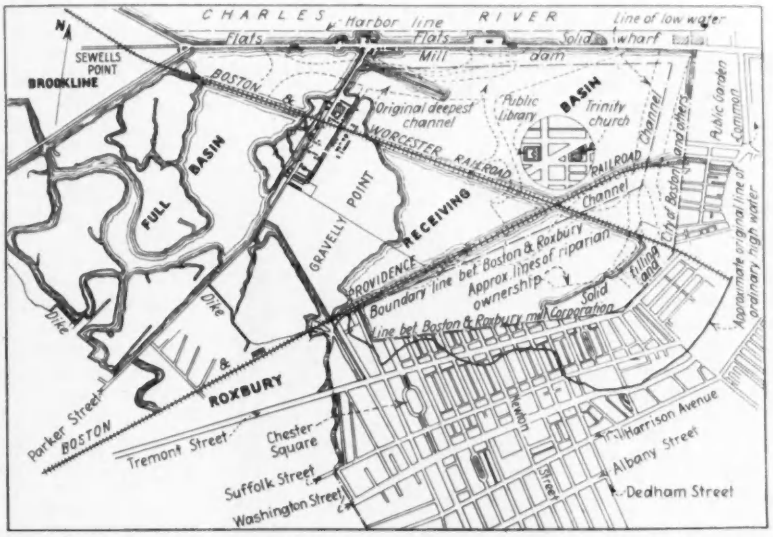


FIG. 1—BOSTON BACK BAY and vicinity as shown on a plan by Ezra Lincoln, Engr., dated March 11, 1852. The insert shows the area considered in this article.

Tracing Loss of Groundwater

Original water table disturbed by underground services is being restored to save building foundations in rich Back Bay district of the City of Boston

By Bayard F. Snow
X. Henry Goodenough, Inc., Engineers, Boston, Mass.

IN THE LAST few years damage to the pile foundations of the Boston Public Library and investigations to determine if a similar hazard threatened the nearby Trinity Church have brought publicity to the phenomenon, long known to engineers, of disturbed groundwater levels in the Back Bay district of Boston. As the groundwater hazards here are such as may come within the experience of other built-up city and industrial areas an account of their origin and correction is of engineering interest.

Early evidence of groundwater problem

The Back Bay in Boston was formerly a part of the tidal estuary which, confined and restricted by embankments and by a dam across its lower course, has become the beautiful Charles River Basin. Long before this basin was constructed, when Old Boston was practically an island and the only land approach was by a road across the salt marshes along the course of what is now Washington St., the Back Bay was cut off from the Charles River by a mill dam and toll road which have become a section of historic Beacon Street extending from the Public Garden to Brookline Avenue. The enclosed area (Fig. 1) was divided into what were called the Full Basin and the Receiving Basin by a dike not far from Massachusetts Avenue, in which were gates and water wheels for power development. Within forty years the Boston and Roxbury Mill Corporation ceased to function and it became evident that these basins had more value as potential building sites than for the development of water power, so that in 1852 the Back Bay Commissioners recommended that the receiving basin be filled in as high as the mill dam, that the dams be made highways, that sewerage and drainage be provided and that the reclaimed area should be laid out into building lots and streets.

Subsequently these commissioners had the filling completed and deep sewers constructed of brick and wood to carry sewage and storm water so that by 1870 this extensive area was available for building sites. Before this the title of the commissioners had been changed to "Commissioners of Public Lands" and their powers had been extended to permit them to convey the property and to place restrictions on its use. These restrictions prohibited cellars below a grade equivalent to El. 12 (Boston City Base).

In 1894, the late Frederic P. Stearns, reporting to the Joint Board on the Improvement of the Charles River, made the following comments upon the groundwater in the Back Bay.

> In this district the buildings are nearly all supported on piles which under existing laws should be cut off not higher than Grade 5, but some of them have been cut off at a higher level.
>
> In 1878, before the construction of the main drainage works, pipes were driven in the ground at various places over the Back Bay district to ascertain the height of the groundwater; and it was found that it was nearly level at Grade 7.7 over the whole district. These observations were repeated in 1885, after the main drainage works had been in operation more than a year, and the groundwater was found at practically the same level as in 1878.

The readings of groundwater levels

taken in 1878 and in later years disclosed certain information and there is no question but that the cause of the low water in certain locations was known to engineers who studied the problem. After citing certain observations showing lower water levels away from the river than those at the nearer observation points, Mr. Stearns continued:

The lower level of the groundwater at a considerable distance from the river in these cases indicates clearly that the height of the groundwater is governed for the most part by leakage into the sewers and not by the height of the water in Charles River.

These quotations show that local low groundwater conditions were attributed to sewers, and the building ordinances requiring piles to be cut off at El. 5 or lower, indicated what was considered safe in this respect. The variation in level from one point to another was noted but data were not as plentiful as they are now, and the definite slope toward the sewers and other indications of the effect of these sewers upon water levels which have been found during an extended study by the writer could not have been as apparent as they are now.

Failures start new studies

About seven years ago the Boston Public Library, built in the heart of the land developed in one of the old basins, showed several alarming cracks. After investigation by the City Building Department and their consulting engineers, it was found necessary to cut off decayed pile heads and replace them with concrete. The tops of some of the piles were completely gone and others were very badly decayed so that for about 40 per cent of the area of the building, underpinning was necessary. The area in which the piles were most affected was that nearest the deep sewer laid in 1912.

Being alarmed lest they might find a similar condition existing or threatened, the trustees of Trinity Church, which faces the Public Library across Copley Square, began an intensive study of the situation. Examination of some of the piles by a test pit showed them to be sound, but indicated a level of groundwater on the south side of the building which was low enough to threaten their safety.

To follow the fluctuations in groundwater, observation wells consisting of 2 in. wrought-iron pipes were driven in the church grounds. Further, to assist in restoring the depleted waters, the roof drainage was discharged into dry wells around the property. These were the conditions when the writer's organization was engaged to advise and assist the trustees early in 1932. Our study of the problem resolved itself into the following parts:

1. A study of the history and the geology of the section with particular reference to the groundwater conditions.

2. A study of the present movement and flow of the groundwater into and from the area and of the effect of any agencies tending to change its normal level.

Geology and history

The following excerpt from the report of W. A. Crosby on the geology of this area clearly shows the necessity of using pile foundations throughout:

For present purposes our history may begin with the deposition of the geologic formations now deeply underlying and surrounding the harbor and estuary. These deposits may be broadly classified in popular terms, proceedings from the bed rock upward and in the order of age, into the bed rock, the boulder clay, the blue clay and the silt or silty sands.

FIG. 2—PILE HEAD removed from the foundations of the Boston Public Library showing type of damage done by lowering of ground-water level.

Over the clay silt and sands of these natural deposits was placed gravel from Roxbury to the height of the Mill Dam (Fig. 1), about El. 12, Boston City Base, the streets being about 6 ft. higher.

With the filling of the basin came the construction of drains and sewers emptying into either the South Bay or the Charles River. Plans in 1863 show that by that time an extensive system had been constructed, but definite records as to location have been since either lost or destroyed. This, together with the fact that they have settled several feet in places, makes the present location of these drains entirely a matter of conjecture, except where they have been uncovered by recent construction. These sewers and drains were the beginning of the present maze of underground channels of which little or nothing is known, but which form channels by or along which the groundwater can escape to sewers in which the gradient is at a sufficiently low elevation to help to drain the area.

Following the filling of the basin, the Back Bay developed into a first-class residential and business district with many large and expensive buildings having a valuation of well over $100,000,000. The foundations of all but the more recent of these buildings were supported on wood piles which were cut off at or near El. 5.

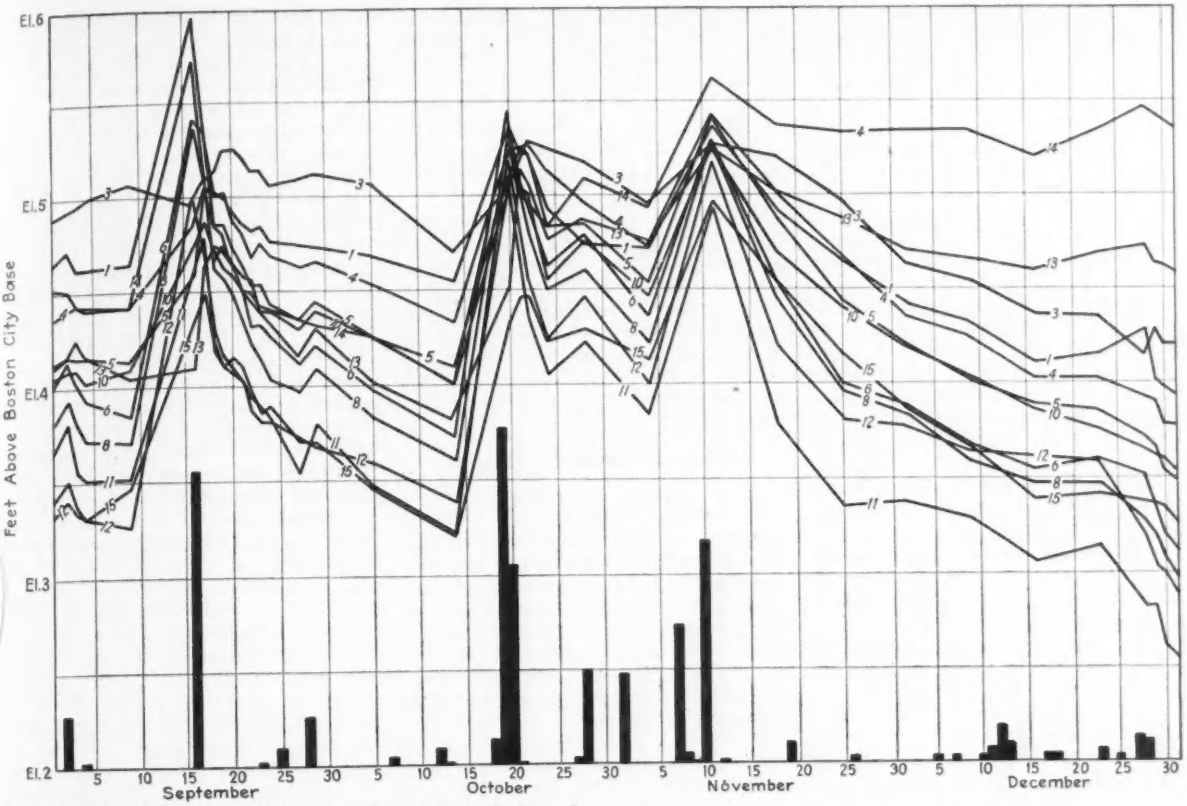
With the residential development of the portion of the Back Bay adjacent to the Charles River came the demand for the improvement of its appearance and the elimination of the odors arising from the tidal flats which were exposed at low tide. A half-tide dam to maintain the water level in the basin at El. 8 was proposed by Frederic P. Stearns in 1894 and again by John R. Freeman in 1903, but the construction of the dam was not completed until 1910.

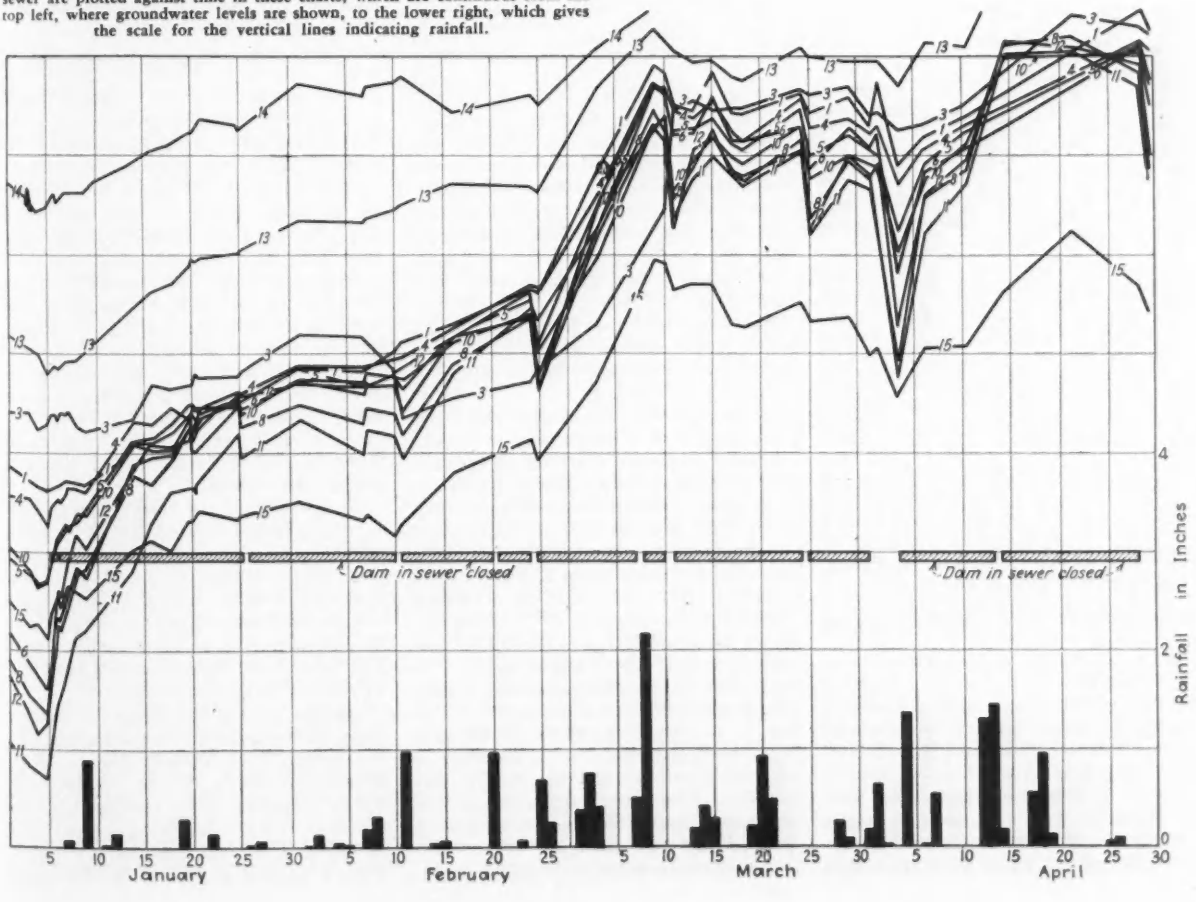
A large sewer known as the marginal conduit was constructed along the Boston side of the basin at the same time to intercept the flow from sewers formerly discharging into the Charles River. The tight sheeting used when excavating for the conduit was left in place on completion.

The Charles River Basin appears to have had little effect on the groundwater level in the Back Bay, except at points near the shore where the minor influence of the former tide cycles was eliminated. The sheeting along the marginal conduit formed a barrier which might be expected to prevent the free flow of groundwater from one side to the other, but appeared to have little effect on the water level in the Back Bay area. The records indicate that at intervals in the sheeting, gates were placed which could be opened if it became necessary to pass groundwater from one side of the barrier to the other, but there seems to be some doubt whether pipes were provided to carry and distribute this flow, or whether the gates were ever operated.

Between 1910 and 1912 the present system of low level sewers was built in the Back Bay. The sewer in St. James Ave. along the south side of the Trinity Church property is of mass concrete, 30 in. in diameter, with its invert at about grade 0. A 30 in. circular drain was built in the same trench about 6 ft. above the sewer to care for surface and roof drainage. All of the sewers in this section discharge into a main interceptor leading to the pump station from which the sewage is pumped through an outfall into the harbor. The sewage level is thus independent of the tide level and is maintained at whatever grade the hydraulic capacities of the various sewers will permit.

Examination of the sewer in St. James Ave. during our investigation revealed that the concrete was in excellent condition and no leakage into it could be





Groundwater levels, rainfall, and the operation of a dam in the St. James St. sewer are plotted against time in these charts, which are continuous from the top left, where groundwater levels are shown, to the lower right, which gives the scale for the vertical lines indicating rainfall.

detected. The examinations were made from the manholes with the aid of lights and mirrors and were unsatisfactory because of steam and the depth of the sewage.

In 1913 and 1914 a subway was built through the Back Bay along Boylston St., parallel to and one block north from St. James Ave., forming a dam and completely cutting off the southern part of the area from the Charles River. In the vicinity of Trinity Church, the subway structure extended from El. 8 to El. 20. Although those in charge of the construction said that it was built on pervious material through which the water could flow freely, it is obvious that a barrier of the magnitude of a subway must cause considerable obstruction to the free flow of groundwater.

Along with the other improvements in the area came more buildings and the paving of the streets. At the present time, somewhat over 80 per cent of the entire area is covered with buildings or paved surfaces. Water falling on these surfaces and carried off by the drainage system obviously does not replenish the groundwater supply and it has been the opinion of many that this was the most important factor in the low level throughout the area.

The basements and sub-basements of many of these buildings extended well below the normal groundwater level and although attempts to waterproof them were made when they were built, either such attempts were unsuccessful or subsequent settlement has caused cracks to develop; 26 sump pumps of widely varying capacity have been found in buildings in this section. In some cases kitchen and other wastes are allowed to flow into sumps so that it is impossible to gain an accurate idea of the amount of groundwater that is pumped to the sewers. In one instance it was found that a building was taken from the ground around the building over 10,000 gal. of water per day. In another it was found that to prevent water leaking in through the floor and walls of the low basement, a series of pipes had been put through the walls to relieve the pressure. From the pipes about 30,000 gal. per day flowed to a sump from which it was pumped to the sewer. Except in the above two cases, it has been impossible to locate definitely the points of groundwater removal, although it is known that a substantial quantity is collected in the subway.

Early water level records fragmentary

Little is known of the behavior of the groundwater prior to the beginning of our investigation in 1932. A number of 2 in. wells had been driven at isolated points throughout the Back Bay by different departments of the city and occasional readings had been taken. Most of the work had been done to study specific construction problems and apparently little or no attention had been paid to the groundwater conditions in the entire area nor to the effect of rainfall. We found that records of the groundwater level were made in 1911, 1912, 1917, 1920, 1921, 1926 and 1929. From 1932 on, regular and frequent readings have been taken and the changes in water level are followed closely.

The elevation at which water was found in the excavations for some of the structures built in the area gives some idea as to the general water level. However, it must be realized that such isolated water levels are affected by local conditions which may be temporary as well as by the amount of rainfall occurring immediately prior to such observations.

Effect of subway construction

It is reported that just prior to the construction of the subway in 1913 the water level on both sides of Boylston St. in which the subway was built was found at El. 8. Pumping during the construction lowered the water level to El. 2, but after the pumping stopped the water went back to El. 6. At other points building construction or alterations disclosed water levels as given below:

Year	Location	Elevation
1920	John Hancock Insurance Company	2.7
1922	John Hancock Insurance Company	6.0
1924	Parish House, Trinity Church	7.0
1926	University Club	4.0
1928	Y. W. C. A.	4.0
1930	Professional Arts Building	6.5

Until 1926 the records of groundwater level as found by building and other excavations and the available well readings give no indication of dangerously low water levels except in 1920 at the John Hancock building, and this may have been due to temporary local conditions. From 1926, however, there appears little doubt that over a considerable area south of the Boylston St. subway, the normal groundwater level was lower than desirable to preserve wooden piles at El. 5.

It must be understood that these various scattered observations represent only the conditions when and where they were made, and that conclusions as to a general condition are not warranted. With this in mind and considering the theories that have been advanced of the cause of the lowering of the water level between 1924 and 1926, the following was most plausible. In 1925 there was an earthquake which was plainly felt and which caused some slight damage in this area. It is contended that during the earthquake cracks developed in the low level sewers and their connections. This seems entirely possible but there is also a probability that the general settlement of the entire area which is taking place is responsible for at least a part of any such damage.

As soon as practicable after beginning the investigation in 1932, a system of readings at all of the observation wells in the area was established. The church had twelve wells around the outside of the building as well as two observation points in the basements. These wells were 2-in. open-end pipes driven by ordinary wash boring methods 18 to 20 ft. into the filled ground. In the earlier wells the lower section and in some of the later ones the entire pipe was perforated to permit easier entrance of the water. In private property the wells were capped with a regular pipe cap screwed on hand tight. Those in the streets were at first provided with screwed plugs which required special wrenches to open but later due to difficulty in removing the plugs, the wells were driven somewhat below the surface and a regular gate box and cover were placed over them.

Readings of the water level were taken and recorded to the nearest one-hundredth foot. A metallic tape with a cupped weight attached was lowered into the well until the bottom of the weight touched water, when the distance from the top of the well to water was noted. Levels had been run to establish the elevations of the tops of the wells, so that all water elevations were referred to city datum. When the cupped weight struck the water surface, it produced a very distinct sound making it possible to get consistent readings in a minimum of time without the use of cumbersome equipment.

Levels checked against rainfall

The results of the readings were plotted on a continuous time-elevation graph (Fig. 3) and the behavior of the water level in the different wells was closely watched. Rainfall was plotted on the same graph so that its effect could be observed. Many sets of readings were necessary before it was possible to arrive at any conclusions because of the continual fluctuation of the level in and between wells and because of temporary or local conditions. Some of the wells would rise and fall rapidly during and following a rainstorm while others either more remote from the influences or located in less favorable water-bearing material would respond much more slowly.

As a result of the early groundwater readings, it was decided that more wells were necessary. Nine observation wells were driven by the church at a cost of $45 each. These, with the permission and cooperation of the city authorities, were located in areas which had been shown by the earlier readings to require further investigation.

As the data accumulated, it became apparent that water in certain areas was consistently lower than in others. Maps showing contours of the groundwater level, prepared from readings at the various wells, clearly indicated the existence of several areas of low water. Fig. 4 shows a typical groundwater

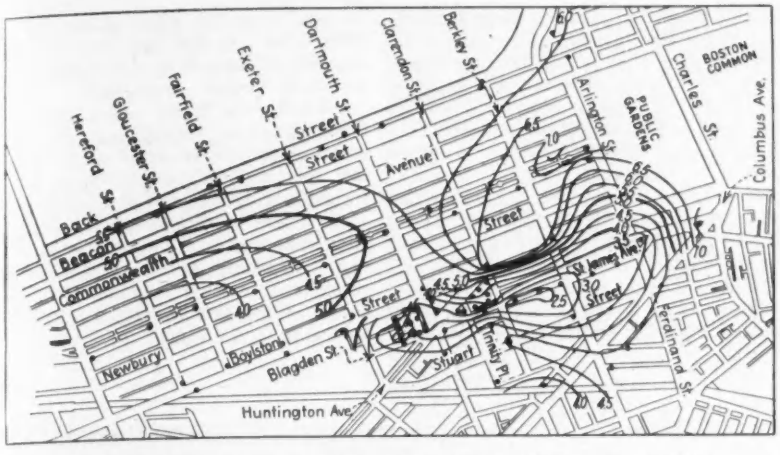


Fig. 4—Typical groundwater contour map showing relationship between area of low groundwater and low-level sewer in St. James Ave.

contour map and the relationship between the area of low groundwater and the low-level sewer in Saint James Avenue. The evidence of observations that the sewer was one of the major causes of the low water was in harmony with the conditions at the Public Library where most of the decayed piles had been found as previously stated on the side nearest the sewer. The city authorities had been most helpful and willing to undertake any reasonable program of determining the facts, and it was with their full cooperation that more wells were driven at selected locations on both sides of the sewer between the lowest holes, thus giving further data as to the low area, but not definitely locating the trouble.

Attempts to locate leaks were made by introducing uranine dye into the lowest well and watching for its appearance in the sewer, but these attempts were not successful. Attempts were also made to locate any such leaks by examining the interior of the sewer with the aid of lights and with mirrors on rafts but proved unsuccessful because of the large flow of sewage and the presence of steam and other obstructions to vision.

It was recognized that the underdrain built under the sewer to drain the excavation at the time of its construction and the presence of many old and forgotten drains and sewers which crossed or went under the sewer, provided channels which could conduct water for long distances underground before reaching an outlet at a sufficiently low elevation to cause a dangerous groundwater condition. An attempt to trace the flow of water from the points of low level to its entrance into the sewer must necessarily be difficult and of doubtful value. One of these old wooden box drains lay between Boylston St. and St. James Ave. and passed under the church and the library. This was uncovered during the work of re-capping the piles under the library. At one point the water appeared to be stagnant and have no flow, while at another the water seemed fresh and indicated a flow somewhere. Later a connection between what was thought to be the same drain and the present low level sewer was found at a point about a quarter of a mile east from the church. There was a small flow from the connection at the time it was examined but not enough of itself to cause any appreciable lowering of the water level. It was also learned that it had been the practice of the city to make connections between such old drains and the sewers because some of the older buildings were still believed to be connected to them.

Trial dam in sewer gave direct results

Because of the indications of relationship between the deep sewer and the areas of low water and because of the aroused interest of some of the property owners, the city officials agreed at a conference in November, 1932, to construct a dam in the sewer to raise the level of the sewage to El. 5. It was felt by all that this would prove conclusively whether or not groundwater leaked into the sewer in sufficient quantity to cause the prevailing conditions. This dam which was completed on Jan. 5, 1933, was built in Dartmouth St. near Boylston and consisted of a special manhole with a crosswall in which was a butterfly valve to facilitate flushing.

Pumping during the construction of this dam took a considerable quantity of water directly from the old underdrain under the sewer. This caused the water level in all of the test wells to fall sharply and a number of wells in the area went dry for the first time at grades below El. 2. This definitely proved that the underdrain would carry water for a considerable distance even though it may have been plugged on completion of construction.

The gate in the dam was first closed on Jan. 5, 1933, and immediately the water level throughout the area began to rise (Fig. 3). The lowest wells that were nearest the sewer rose fastest along the entire length of the sewer above the dam. Wells further away were slower to respond but all of the wells in the area showed the effect of closing the gate. The rise was similar to the recovery of water level after exhaustive pumping in a well field, very rapid at first and gradually becoming slower. Rainfall during the construction and recovery period was definitely subnormal.

Although the dam was first discussed as an experiment to prove or disprove a relationship between the sewer and the low water level, the results of its operation were so beneficial that it has remained in use since to maintain the groundwater level in the district.

Periodic opening of the gate has been necessary to flush the accumulated sludge out of the sewer. Readings of the groundwater level at such times show a rapid falling off with a corresponding rise in levels after the closing of the gate.

Since the closing of the dam, the Sewer Department has conducted experiments attempting to locate the points of leakage into the sewer, but with the foundation piles again covered with water, much of the anxiety of the property owners has been relieved.

Possible groundwater replenishment

During our investigation, pumping for the foundation of the Christian Science Publishing House, about one-half a mile from Copley Square, afforded an opportunity to observe the effect of pumping on an area of restricted groundwater replenishment. As has been previously mentioned, the surface is nearly 80 per cent impervious and the flow in from the Charles River Basin is obstructed by the marginal conduit and by the subway, so that the available flow of groundwater in the area has been restricted. The foundation area at the publishing house was de-watered by a system of well points which maintained the water level at El. 9, while pumping approximately 1,000,000 gal. daily. Observations made in the Public Library about one-half mile distant showed definitely that the groundwater levels were affected by this pumping.

Notable construction having occurred in this area in all but six of the preceding 21 years, and the water level necessarily being lowered for considerable periods during such construction, it is entirely possible that the beginning of the decay found in the library piles had occurred long before the general low groundwater level of the area was established.

Twice during the investigation, the water level in certain of the wells was found to be considerably above the normal level for the well or the area. Investigation by the water department revealed a broken water main in one instance, and a broken service pipe in the other, both of which were permitting

considerable leakage into the ground without showing any evidence on the surface. The effect of such leakage was purely local, however, and the general level was not raised.

We have been able to trace to some degree, at least, the effect of rain on groundwater levels. A number of the wells responded very quickly and the level fell again almost as fast for several hours, after which it continued to fall at a gradually diminishing rate. On the diagram Fig. 3 the observed points are connected by straight lines, which naturally flattens the slopes and indicates a slower response to the influences causing a rise and fall in level than is actually the case. It is also apparent that only by chance would we get the highest level resulting from a rain. The rapidity with which levels fell below El. 5, however, shows the existence of channels of considerable hydraulic capacity and indicates the difficulty with which a safe groundwater level could be maintained by replenishment, which was one of the methods considered.

The variation in water levels with rain, pumping, relation to drains and other disturbing factors shows that occasional scattered observations are of little value and that data of real value can only be secured by having many observation points strategically located and reading the levels consistently. The importance of having enough such points appears to be corroborated by the fact that a WPA project, now being carried out by the city of Boston, provides for the driving of several hundred additional wells. If water levels are read frequently at all of the points which will soon be available, the behavior of the groundwater will be better known in the future.

Fighting Snowdrifts

Annual 300 to 600-in. snowfalls where Rocky Mountain roads cross the Continental Divide present special tasks in snow control and removal—State departments cooperated with Bureau of Public Roads

By Clyde E. Learned
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EQUIPPED to open up the snow blocked forest and park roads under its administration in the Rocky Mountain states, the Bureau of Public Roads acts as the agency for many of these states in keeping their across-mountain highways open for winter travel. Through this experience the bureau engineers have worked out snow-removal and control practices of high efficiency and have accumulated unique records of snow conditions. This article by Mr. Learned, condensed from a paper presented at the Highway Engineering Conference of the University of Colorado held Jan. 16 and 17, presents a striking picture of one of the less known actions of the annual battle of modern road transport with winter snow and cold.
—EDITOR.

MAINTAINING an open road throughout the winter or opening a snow-blocked highway in the spring in the lofty regions of the Continental Divide presents problems and introduces methods not commonly found at lower elevations. The highways to be discussed are located for the most part between elevations 9,000 and 12,000 and are in regions where the snowfall ordinarily ranges from 300 to 600 in. per year and where it is not unusual to have a snowfall during every one of the twelve months. The methods described are those employed by the forces of the Bureau of Public Roads in the national forest and national park areas of this district, which includes the Rocky Mountain states of Colorado, Wyoming, and New Mexico. In many instances, cooperative agreements have been prepared which provide that the state set up the necessary funds and the bureau performs the snow removal work in conjunction with its regular maintenance operations.

Volume of snowfall very large

The bureau's most extensive snow removal operations have been on the Berthoud Pass Forest Highway. This is the heaviest traveled transcontinental route in Colorado, and crosses the divide at elevation 11,306 ft. The snowfall for the past four years ranged from 316 to 507 in. with an average of 416 in. Last winter and this winter [1935-36] arrangements were made for snow removal on the 25 miles of the Tennessee Pass project between Leadville and Red Cliff and on 12 miles on the eastern slope of Fremont Pass. Although the elevation of Fremont Pass is about the same as that of Berthoud Pass, the snowfall for the past two winters has been considerably less, the fall during 1934-35 having been 276½ in. as against 439 in. on Berthoud. During the same period the snowfall on Tennessee Pass was 243½ in., this being about 10 per cent less than Fremont and 55 per cent of the fall recorded on Berthoud. Bureau records also appear to indicate that Rabbit Ears Pass has a little more snow than Berthoud—the 1932-33 records showing 535 in. as against 507 in. on Berthoud. Unquestionably two of the heaviest snowfall regions are the areas adjacent to the Trail Ridge project in Rocky Mountain National Park and the Centennial-Saratoga project across the Snowy Range in southern Wyoming.

Ordinarily March and April are the months of heaviest snowfall. The Berthoud Pass records disclose a fall of 154 in. during April, 1933, while the Tennessee Pass records show a total fall of 81 in. during April, 1935. On Rabbit Ears Pass heavy snowfalls during March and April are customary, but on this particular pass, December appears to have a slight edge due to a 107-in. fall during December, 1934.

Among individual storms, the blizzard of April 19-22, 1933, still holds first place, this one storm having deposited a total of 96 in. of snow on top of Berthoud Pass. The same storm deposited 53 in. of snow at the Weather Bureau Station near Frazer, the western terminus of this project, at elevation 8,600. At the height of the storm, 36 in. of snow fell during a 13-hour period, with hourly falls of as much as 4 in. During February of the following year, a storm of record intensity hit the Berthtoud Pass project and between 6 and 7 in. of snow per hour was measured in that area during a two-hour period.

The snowfall is ordinarily greater on the western slope of the divide than on the eastern slope. It is not uncommon to have a 10- to 12-ft. accumulation of packed snow on Berthoud Pass which extends down the western slope, and have the depth on the eastern slope taper off so rapidly that the ground is bare at Empire, the eastern terminus, at elevation 8,600. Day after day on Berthoud Pass the sun may be found shining on the eastern slope, while unsettled and stormy weather prevails on the western slope. The records indicate that snow falls sometime during the day on nearly one-half of the days during the winter.

Many remedies and devices have been employed to cope with the numerous and varied tasks presented on these high altitude highway projects which it is desired to keep open throughout the year. For the sake of convenience these may be grouped under three heads—prevention, control, and disposal.

FIG. 1—OVER BERTHOUD PASS, 11,306 ft. high, where the snowfall ranges from 300 to 500 in. traffic has been maintained with the aid of plowing operations using push and rotary plows.

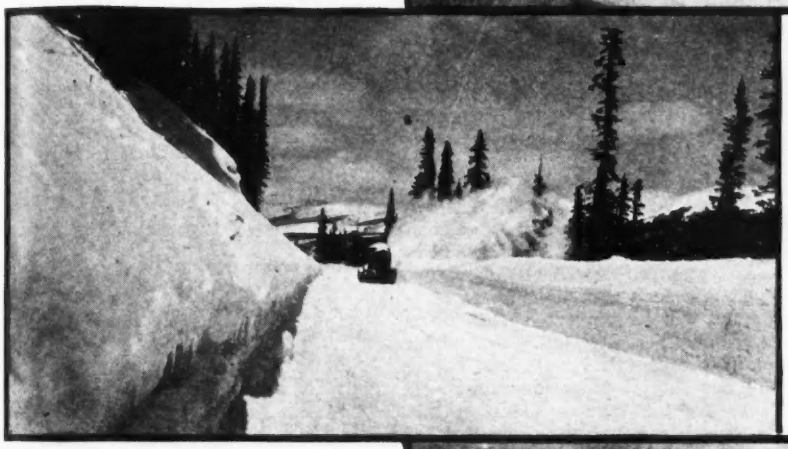


FIG. 2—TRIMMING and smoothing a 24-in. opening on the road over Berthoud Pass. This road is a forest highway and is maintained by the U. S. Bureau of Public Roads.

FIG. 3—OPENING RABBIT EARS Forest Highway in May for Summer travel. The rotary plow is cutting through 4 to 6 ft. of snow packed to a weight of 30 to 40 lb. per cubic foot.

FIG. 4—PLOWING IN MAY for the Summer trade on the Trail Ridge Road in Rocky Mountain National Park. This rotary plow is cutting through accumulated snow 20 to 30 ft. deep.

Prevention depends primarily on the work of the highway engineer, since it involves highway location, design and construction. Remedies have included raising the grade to get the benefit of the sweeping action of the wind, thinning trees or flattening cut slopes to get better exposure, keeping the roadside free from brush and weeds, and locating through wooded areas to obtain a maximum of protection against drifting.

Rabbit Ears Pass

The Rabbit Ears Pass highway, the upper ten miles of which traverses a wind-swept region, probably illustrates better than any other in this district the methods employed in design and construction to combat nature's elements. All grades were elevated above the surrounding terrain, and wherever sidehill construction was involved, the road section was thrown out as far as feasible from the mountain cut slopes. Where ridges had to be pierced, the through cuts were made wide with broad flat ditches on both sides and in many locations light fill sections were actually superimposed on a through cut section.

During the bureau's maintenance period on Rabbit Ears Pass, the engineers have studied drifting conditons and determined the direction of the prevailing winds, with the result that in many instances the maintenance crews have widened, flattened and rounded the through or sidehill cuts and created airflow sections; that is, sections which introduce a minimum of interference or resistance to air currents, and which have actually reduced drifting at a number of locations.

Prevention also includes the construction of intercepting ditches and underdrains to prevent both surface and underground flows from reaching the traveled highway. With the advent of the oiled or bituminous-surfaced road, these drainage items have assumed a new importance as the small amount of moisture that was so desirable in a graded or crushed surface road is found to be disastrous to an oiled road. For a number of years one of the biggest items on the bureau's maintenance and post-construction programs in the National Forest and National Park projects has been the installation of extensive systems of tile and rubble underdrains to cut off and control water-bearing strata. On the Trail Ridge, Tennessee Pass and Berthoud Pass projects, miles of underdrains have been constructed during the last few years, all of which are functioning in a very satisfactory manner. The winter of 1934-35 is the first that ice has not blocked the ditches and formed dangerous ice mats across the Berthoud Pass highway. In previous years the bureau spent as much as $2,000 a winter in removing and attempting to eliminate these ice formations on this highway.

Control work is practically all confined to the placing of temporary or permanent barriers to reduce snow drifting. The temporary barrier takes the form of snow fence, the most common type used on bureau work being the wire-connected slat type. Ordinarily this is shipped in 100-foot rolls and is easy to install and take down for summer storage. There are many locations with heavy snowfall and severe wind action where this type of fence has been erected to a height of three tiers or 12 ft.; the second and third tiers having been added as the under sections became buried in snow. On some projects the lower branches of trees have been removed and low growing shrubs cut out; also old rail or log fences have been replaced with wire fences to reduce drifting on the highway.

Permanent control takes the form of tree planting. Although very little of this class of work has been performed, there are a number of favorable locations such as across portions of the Rabbit Ears Pass range and the Crane Park section of Tennessee Pass where exceptional opportunities are presented.

Due to the expense no effort has been made to control snowslides although it is felt that such undertakings are feasible and will be warranted later, when traffic increases. Of the passes which are kept open, Berthoud Pass is the only one subject to major snowslides. There are the regular slides on this pass which occur at the same location year after year, and there are also slope slides or slips which may occur at any location where there are steep banks above the highway. The latter are usually minor in character and do not cause much damage. The maintenance men keep watch of the overhanging snow cornices on this project as they build up on the tops of the mountains or ridges above the road. Barricades and signs are put up at both ends of the project to keep the traveling public out of the danger zone whenever conditions appear to be dangerous, which is usually during the latter part of February. As soon as the slide occurs, which is generally during the night, the rotary snow plow is brought into action. Considerable hand work is required to cut a traffic lane through the reinforced mass since the slides usually deposit quite a cargo of trees, logs and rocks on the highway.

Snow disposal methods and equipment

For actual removal of snow from the highway, the bureau has adopted in most instances heavy duty four-wheel drive trucks which are capable of fairly high speeds. All trucks are equipped with reversible-blade plows, no V-plows being included in the equipment, since practically all of the work is on mountainsides, where all the snow must be pushed to the outside edge. In addition to the regular headlights, all trucks are equipped with two powerful spot lights for night driving.

Tractors which were included as equipment a year ago are objectionable for snow removal on isolated projects because it is not feasible to get them back to a heated garage at night on account of their low speed. The bituminous wearing surfaces also prohibit the use of tractors for snow removal since the grousers necessary for traction are very destructive to the surface and shoulders.

Men of stamina needed

In the operation of trucks in regions of heavy snowfall, the practice has always been to send two men capable of exchanging places with each truck and plow. The men in the snow-removal crew are usually the pick of the maintenance organization. They are selected because they are physically fit, are interested in the work, respond in an emergency, and are familiar with the highway alignment and every feature of the landscape. A blinding snowstorm during a night run is no place for an inexperienced or timid operator of snow-fighting equipment.

On the passes upon which open roads are maintained, truck plows are started as soon as 2 or 3 in. of snow has accumulated, and the equipment is kept continuously in operation day and night during the period of the storm. When the snowfall is heavy, the rotary plow is brought into action to pick up the snow and throw it down the mountainside or with the wind as soon as the truck plows have pushed and piled sufficient snow in the windrows along the outside of the cleared path. Besides reassuring traffic which may have ventured into the storm, this working with the storm reduces the opportunity for snow to pack under traffic and build up a thick snow mat which is difficult to remove.

At the lower elevations where the snowfall is not excessive, the aim is to remove the snow and ice from the highway or to treat with sand. This practice is practically out of the question and would be a futile undertaking at the higher elevations adjacent to the tops of the passes. On some of the passes snow is recorded on nearly one-half the days during the winter and if an effort were made to remove the mat or spread abrasive material, either new snow or wind action would continually nullify the work.

The spring opening of a mountain pass which has been blocked by snow all winter usually introduces a number of conditions and problems not found on the highway which is kept open throughout the winter. The Trail Ridge route in Rocky Mountain National Park is an example of a "closed through the winter" highway. A brief description and a few details of this highway are given for the benefit of those who are not familiar with the Trail Ridge high-

way, which is said to be the highest through auto road in this country.

The construction of this highway differs from most of the other mountain roads in the Rocky Mountain region, because no attempt was made to find the easiest and least expensive route through and over the mountains. Instead, the highway was constructed through a region of the roughest character in an effort to reach commanding positions where widespread panoramas and magnificent views could be obtained of the concentration of peaks, lakes and canyons for which this region is famous. As a result the most inexperienced mountain driver is now able to drive his car in high gear far above timberline into a region of extreme heights and spectacular views which were previously accessible only to the hardy mountain climber.

Snow removal started in May

This highway connects the east and west entrances of the park. Coming from the Grand Lake or west end, the Continental Divide is crossed at Milner Pass about two miles above sea level. The highway then continues skyward across Fall River Pass, elevation 11,800, and on toward Iceberg Lake and Monument Ridge to a maximum height of 12,185 ft. Over 20 mi. is above elevation 10,000 and 4½ mi. above elevation 12,000. It is necessary to start snow removal operations during the forepart of May to open this road to traffic by June 15, the usual official opening date. It ordinarily requires at least six weeks of long hours and strenuous efforts to get the route open and in a passable condition for the heavy tourist traffic.

As much of the highway traverses a barren windswept region far above timberline, it is necessary for the snow plows to cut through deep drifts to open a passageway for traffic.

In the opening of this pass, the bureau uses a Park Service rotary snow plow of the auger and blower type. This is supplemented by a number of heavy duty four-wheel-drive trucks which are used in the lighter cuts and also to assist the rotary on widening and cleanup operations. In deep packed snow a number of men are kept at work breaking and shooting down the higher drifts so that the rotary plow can handle them. As the weather during May and June above timberline is sometimes very bad, it is often necessary to retard the advance upward and turn back and open the snow-filled road behind in order to move in supplies and get the men to and from work. In clear weather the men must be protected from sunburn and snow blindness, as the glare of the sun on the broad expanse of snow is terrific.

The snow encountered weighed from 6 to 33 lb. per cu.ft. The average for the new snow in drifts was 12 lb. while the old packed snow averaged 22 lb. per cu.ft. The average for the entire mass encountered was about 17 lb. per cu.ft.

In packed snow weighing from 20 to 33 lb. per cu.ft., the rotary picked up and threw out 1.8 to 6.3 tons of snow per minute. The maximum output was in snow from 2 to 3 ft. in depth, and the minimum in snow over 5 ft. in depth. In snow ranging from 6 to 14 ft. in depth, the efficiency of the rotary plow was materially increased by blasting, the output of blasted loosened snow from the rotary being fairly constant and averaging about 3½ tons per minute.

In the opening of the highway a total of 120,000 tons of snow was moved, of which about 77,000 tons was old packed snow. The balance of 43,000 tons was new snow which fell or drifted in after operations were started. The entire mass of snow was moved at a cost of about 4 cents per ton. Expressed in units which may be a little easier for most engineers to visualize, over 500,000 cu.yd. of drifted or packed snow was moved for a little less than 1 cent per cu.yd. These unit costs are about double the Berthoud Pass unit costs. In both the Berthoud Pass and the Rocky Mountain Park work, the average weight of the packed, drifted and windrowed snow was found to be the same, namely, 17 lb. per cu.ft. The increased cost of Rocky Mountain Park work is to be expected and was due to the need for explosives and the use of more labor in connection with the shooting down of the high drifts so that the rotary plow could handle them. During the entire period that the rotary plow was in action, the average output was 3.2 tons per minute. This is equivalent to about 11 cu.yd. of old packed snow, or 20 cu.yd. of newly drifted snow per minute. In general, the observations indicated that the output of the rotary varied materially with the depth of snow but not appreciably with the weight.

Opening this highway in the spring of 1935 cost $4,536, which was distributed 33 per cent to labor; 31 per cent to materials and supplies, which included 3½ tons of explosives; and 36 per cent to rentals. Although various brands and grades of dynamite ranging from 20 to 60 per cent were used, the results were such that no definite conclusions could be drawn. However, it was demonstrated conclusively that snow should be blasted only a short distance ahead of the rotary plow since blasted snow readily packs again, and if left for any period of time, requires reblasting.

Soil-Thread Rolling Device

By Jos. A. Leadabrand
Champaign, Ill.

THE LOWER plastic limit of a soil is defined by the Bureau of Public Roads as being that moisture content at which the soil can just be rolled into a thread ⅛ in. in diameter. The accepted method of determining this value has been to add water to the soil, mix thoroughly and roll out into a thread by using the palm of the hand. The resulting thread obviously may be from 1/16 in. to ¼ in. in diameter depending upon the judgment of the performer.

For the same soil, the writer could not check previous results any closer than by 5 to 10 per cent. After making the test ten times with a soil of predetermined plastic limit of 21 (determined by the Bureau of Public Roads), it was found that the average value of the ten results was 20.93 but the individual values were 21.6, 19.3, 20.4, 20.8, 18.7, 18.6, 21.3, 22.1, 23.8, 22.7. While the average value of these tests was practically 21.00, the fact remains that no one test gave the correct result. The writer then undertook to devise a method of getting more definite results.

The apparatus devised is very simple and easy to construct. It consists of two ground glass plates, one 8x8 in. and the second 4x4 in. and two pieces of ⅛ in. diameter hard steel rods. The steel rods were fastened rigidly as runners to the smaller glass plate. As shown by the illustration the procedure by this device

is the same as described by the Bureau of Public Roads, with the exception that the thread is rolled between the glass plates instead of under the palm of the hand. The ⅛ in. wire runners relieve the operator of the necessity of judging the diameter of the soil thread; it is definitely ⅛ in. in diameter.

In twelve tests made on one soil, the results did not vary more than 3 per cent from the value as determined by the Bureau of Public Roads. Persons other than the writer performed tests for a soil by using the glass plates and by using the palms of their hands. The results obtained by use of the hand varied from 4 per cent to 20 per cent of the value as the writer had previously determined, while those obtained by the glass plates varied from 0 per cent to 5 per cent.

This method of determining the lower plastic limit was devised as a part of the work being done for a thesis on soil mechanics. The work was done in the Highway Soils Laboratory at the University of Illinois.

Earthquake-Proof Earth Dams

Five storage dams on water-deposited soils over the shattered and shaken bed rock between the historic San Andreas and Hayward faults in California have earthquake resisting sections

By F. H. Tibbetts
Chief Engineer, Santa Clara Valley Water Conservation District

EARTH DAMS designed to resist earthquake shock have been adopted for five storage dams now being constructed in the Santa Clara valley in California. Frankly accepting the possibility in this district of seismic earth disturbance perhaps of major magnitude it was planned to produce an earth fill that would readjust itself after rupture to restore watertightness. This, it is the consensus of the expert thought brought into consultation, has been accomplished by a modified disposition of pervious and impervious sections of the fill.

Satisfactory earth dams can be built anywhere using any kind of material, in the opinion of the writer, provided (1) the upstream portion including the cutoff trench extending into the impervious foundation material is made impervious and (2) the rear portion has sufficient bulk and porosity so it will drain off, without sloughing, any water which seeps through the impervious portion. In describing the upstream material as "impervious," the intention is to indicate that it is more nearly watertight than the downstream portion. The latter may be anything from coarse earth or sand to gravel or loose rock.

This theory has been applied in the construction of the five roll-fill earth dams built for the Santa Clara Water Conservation District located on the five principal streams flowing into the valley. Each of the streams has found its way either into fault lines or into geological contact lines and at four of the five sites there is complete geological non-confirmity on opposite sides of the stream. Not only are the foundation materials deeply weathered but they are shattered, broken and of highly variable quality. Nevertheless, it has been possible to construct earth-fill dams at these sites in such a way that they are believed to be safe from destruction even in the heaviest seismic shocks ever experienced in this region.

Groundwater replenishment planned

The Santa Clara Valley, whose lower end terminates where the south arm of San Francisco Bay begins, is bounded on the west by the range of hills which continues on northward to form the San Francisco peninsula. The main portion of the lower valley floor, almost level, is an area of high fertility and includes about 130,000 acres which was organized in 1929 into the Santa Clara Valley Water Conservation District for conserving and developing the water resources of the region.

FIG. 1—IN THE CUTOFF TRENCH looking toward the left abutment of Coyote Dam. The vertical face in the background, covered with gouge, is the main slip plane of the Hayward fault. The cutoff trench was excavated below the foundation level which shows at the extreme left.

In the past 20 years irrigation has increased rapidly throughout this valley using water pumped from wells. More than 2,000 pumping plants are in operation and except for perhaps 10 per cent of the area that is covered by urban development, the entire valley is under intensive cultivation with correspondingly high water duty. Under these conditions the water table has been lowered steadily; in the past 20 years pumping lifts have increased 100 ft. or more and the cost of power for pumping has increased to $665,000 annually. The assessed valuation within the area comprising the District is about $85,000,000 and the total population is about 110,000.

From long-time records it is estimated that the average total runoff into the valley floor is about 202,000 acre-ft. per annum, of which 76,000 acre-ft. naturally is absorbed to replenish underground storage and 126,000 acre-ft. wastes into San Francisco Bay. The primary objective of the recently formed conservation district is to capture and store as much as possible of the waste flood water to be released at such a time and rate that it will pass by influent seepage into underground storage. This plan is expected to raise the water table, decrease pumping costs and provide more underground storage that will await beneficial use by way of the pumping plants.

As a background of this replenishment plan it is important to understand the valley geology. The lower end of the valley bordering on San Francisco Bay probably has been alternately above and below sea level a number of times in successive geological periods. The surface soils consist of silt, sand, clay and gravel washed down from the Franciscan shales and sandstones which surround the valley on three sides. The sandstones are of great age, much broken and shattered by repeated faulting and by serpentine intrusions. Two of the major breaks in the California surface topography, the San Andreas and the Hayward faults, pass close to the western and eastern edges of the valley respectively. Movements along both of these faults have caused severe earthquakes in recent times.

The Coyote River is by far the largest of the valley's tributary streams. It comes in from the east side and has worked down into the Hayward fault. Storing flood flow on this stream is essential to success of the conservation plan. In fact, it was found necessary to build the largest of the five dams on this stream actually straddling the active Hayward fault on what is probably as poor a foundation as ever was selected for a large dam. Slips on this fault probably occur on the average several times a century; the last major earthquake resulting from a Hayward fault slip occurred in 1868—a seismic disturbance of intensity probably comparable to the San Francisco quake of 1906. The other four dams, though not in positions of such great risk, all are liable to seismic disturbance and have been designed accordingly.

The underground storage in the valley bottom, on the other hand, is in a formation as favorable as the dam sites are unfavorable. The valley floor is a fill, mostly several hundred feet deep, composed of materials washed down from the surrounding mountains. A study of logs on several hundred wells, spaced as uniformly as possible over the valley, indicates 10 per cent of the substrata is water-bearing gravel or sand. These water-bearing zones or aquifers seem to be buried stream channels very similar to the sand or gravel layers a few feet in thickness at the bottoms of the

present streams; for the most part they radiate from large deposits of gravel or boulders which constitue the alluvial cones of the present streams. In general they follow the present surface drainage and connect at many points. The aquifer material, like that in the beds of present streams, is quite open and porous.

With the aquifers is a thick blanket of impervious clay, thicker and more extensive in the lower end of the valley; the ancient river channels generally seem to have pinched out at their lower ends in this impervious material. As the aquifers are thus buried in material less pervious than themselves, and since they head in the cones whence comes the surface drainage, there has been a tendency to develop pressure under the marine clays of the lower valley. Before the period of general overdraft on subterranean storage the pressures in the lower valley were great enough so that when a well was put down into one of the aquifers the water level occasionally rose above the natural ground surface.

If the aquifers pinch out in marine clays at the lower ends of the valley, as is believed, the underground storage basin is enclosed on three sides and thus has little marginal or terminal loss.

General plan was conventional

Although it was impracticable to provide storage for all the waste flood waters, it was possible to lay out a plan which would conserve two-thirds of it. The major portion of the work recently completed consists of five earthfill dams from 100 to 140 ft. high, all designed with a view to the seismic risk involved. One of the five, the Coyote Dam, designed to store 40,000 acre-ft., actually straddles an active fault and because it is literally poised over a city of 70,000 population, a major consideration in its design was that it should safely hold back the stored water when subjected to the severest earthquakes likely to occur.

The usual cross-section of the dams is a 20-ft. top width with slopes that average 1 on 2½ on each side. Coyote Dam has a top width of 100 ft. and side slopes ranging from 1 on 3½ to 1 on 4. The rear portions are constructed of the most pervious materials available; the front portions are of the most impervious material within economical hauling distance. The line of demarcation between the two materials is indefinite.

The selection as well as the placement of the material in all of the dams, however, was under very careful laboratory control. Mechanical analyses were made daily with two principal objectives: (1) To make sure that the material containing the highest percentage of clay was placed in the upstream portion of the dam and that at any level it was graded as far as practicable from tightest material at the upstream face to loosest material at the rear; (2) To make sure that the moisture content always was within 2 per cent of that amount which laboratory tests had shown to make the densest material. Where the material deposited in fill had less than the required amount of moisture, sprinkling was employed to make up the deficiency. Usually the water content varied from about 10 per cent to 17 per cent. As the material

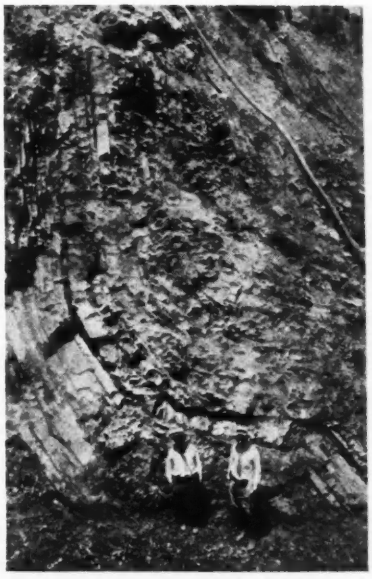


FIG. 2—DISTORTED STRATA in the left abutment of the Coyote Dam. This view, transverse to the fault, shows alternate layers of Franciscan sandstone and shale with typical evidence of fault movement. Cracks and folds usually are normal to the fault plane.

was delivered in layers and sprinkled (where necessary) compaction was obtained by going over the fill with sheepsfoot rollers for which the minimum pressure specified was 200 lb. per sq.in. and the actual pressure available was about 325 lb. per sq.in.

On one of the dams the upstream face was finished with a layer of loose dumped rock. On the other four, however, after the face of the earthfill had been smoothed off it was covered with a 12-in. layer of clean gravel as a support for a reinforced concrete slab 4 in. thick. The slab was laid in panels 16 ft. square with construction joints on all four sides and weep holes in the center. The functions of the concrete facing were to give protection from drift and wave wash, to span pockets of soft material and to distribute the water pressure uniformly to the body of the dam.

Spillway locations were selected with three objectives: (1) To provide straight-line paths for flood waters; (2) to get the best possible supporting material for the concrete lining; and (3), since practically all spillway excavation was used in the dams, to provide the best possible material for the fill. An 8-in. reinforced concrete lining was placed in all spillways.

The outlet control works are steel pipes in concrete-filled trenches beneath the dam base; valves are used on both ends. The upper ends, in trash rack grillages, are closed by slide gates hydraulically controlled from the tops of the dams; the lower ends have butterfly valves manually operated, discharging into reinforced concrete chambers designed to absorb the energy of discharging water. Measuring weirs are included in the energy-absorbing structures.

Several times each year there are minor movements of the Hayward fault that are detectable with seismographs; every 30 or 40 years it gives rise to severe earthquake shocks. Thus the criteria set up for the design of an earthquake-proof dam on or near this fault should include maximum safety when earth shocks occur. Although there have been no instances of important modern dams destroyed by earthquakes and thus no practical examples or proofs of theory exist, nevertheless on this project certain requirements were assumed to be essential in preventing such failures in earthfill dams.

First, the impervious or water-resisting element must be of a sort that cannot be ruptured by shock. This consideration precludes the use of concrete in the form of an arch or as a waterproof facing or as a core wall. If it had not been for seismic considerations probably concrete would have been used at least in the Coyote Dam, where the site is topographically well adapted to a thin variable-radius concrete arch. Such a structure could have been built for a fraction of the cost of the design adopted.

Second, the cutoff wall must be carried down farther than usual so that any cracks opening up under the foundation will not allow water to pass under the dam during an earthquake.

Third, the dimensions, especially of the impervious element, must be such that under no conditions could this portion of the structure be offset, as in an earthquake movement, sufficient to let water through. This calls for some assumption as to the maximum movement probable, both horizontal and vertical, on a shear line passing directly through the dam. The maximum vertical displacement permissible is a function of the freeboard of the dam and, in the case of an earthfill, the maximum horizontal displacement is a function of the thickness of the impervious element.

To provide logical basis for assumption as to maximum movement, a very thorough study was made by experienced geologists of the entire region and of all records of movement along the San Andreas and Hayward faults during the last century. The conclusion was that fault movements might have a horizontal component of about 15 ft. and a vertical component of 3 to 5 ft. The 1871 earthquake in Japan had a horizontal displacement of 13 ft.

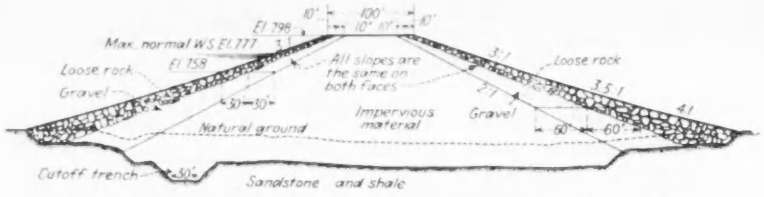


FIG. 3—MAXIMUM CROSS-SECTION of Coyote Dam showing slopes and thicknesses of zones in which different materials were placed. Thickness of rock and gravel layers is uniform for the entire length of the dam.

and a vertical displacement of 19 ft. but evidence in the Santa Clara Valley indicates that movement on the San Andreas and Hayward faults has shown vertical components between zero and one-third of the horizontal maximum, at least in recent times. Based on these observations, the minimum thickness of the impervious element at the top was made four times as much as the anticipated maximum horizontal movement, and a freeboard was provided equal to four times the maximum vertical component.

Fourth, the impervious element must be protected by weighting it down with granular material possessing no shearing resistance, thus providing assurance that the impervious element will be unable to slump during the earthquake.

Fifth, a serious element of danger to a dam built on an active fault is the possibility of movement that would develop tension within the structure. Compression that merely tended to squeeze the dam together would be unlikely to destroy an earthfill but stretching the dam lengthwise would tend to open fissures which might remain open if proper precautions in design were not taken. Thus an important objective in the design adopted for the dams of this district was a type of construction such that if a fissure should be opened by movement of the foundation which stretched the dam lengthwise, the structure instantly and automatically would close up before water could rush through and establish a channel.

Seismic design exemplified in Coyote Dam

The largest of five reservoirs is formed by Coyote Dam, which now can store 30,000 acre-ft. and can be raised to increase the capacity to 45,000 acre-ft. This dam is about 25 miles southeast of San José and, as has been noted, straddles the Hayward fault. Since the youthful days of this fault some millions of years ago it has hunched along about 1,400 ft.; that is, the west side has moved northward by this amount from points on the east side of the shear zone, which appear not to have moved. Some of this movement has been accompanied by earthquakes; much of it has been a slow flow in the soft, plastic Franciscan shales. Conservative design required

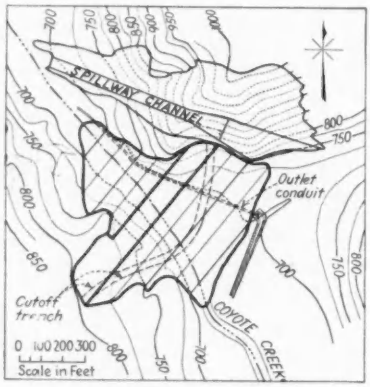


FIG. 4—PLAN of the Coyote Dam showing the location of the major portion of the material upstream from the abutment.

that the Coyote Dam should meet the safety requirements mentioned and should resist, without any danger whatever to the community below, seismic shocks at least three times as severe as any yet experienced. Any weakness or risk inherent in the design of this structure probably would continue to be a menace until the weakness caused failure or the reservoir is silted full.

As in the case of the other dams, the Coyote site was explored thoroughly by test pits and tunnels to determine, first, the character of the underlying material and, second, to show where borrow pits could be located most advantageously. One of the tunnels was driven beneath the river, one through the shale-serpentine contact and one through the gouge on the plane of the recent major movement of the Hayward fault. This gouge was tested in place both for permeability and for bearing power.

As constructed the dam has a normal freeboard of about 21 ft. During any major earthquake this freeboard might be reduced by one-half if synchronized with the maximum flood. To get this combination, however, it is to be remembered that the earthquake, which might continue for a 30-sec. period once in a thousand years, would have to occur during the period of maximum flood, which might continue for 24 hours once in each thousand years. The probability that these two phenomena will synchronize might be interesting exercise for a mathematical gymnast.

The impervious element in this dam is a rolled fill whose section is such as to permit it to stand by itself; it has a 60-ft. top width and 1 on 2 side slopes on both upstream and downstream faces. The cutoff trenches were carried into hard rock after all loose material had been removed from the foundation. Subsequently much of the material removed was put back into the fill, but in so doing care was taken to make segregation on the basis of relative porosity.

Outside the impervious sections on both upstream and downstream faces are blankets of clean rounded gravel 10 ft. thick at the top, increasing to about 90 ft. thick at the base. Outside the gravel zones blankets of rockfill were placed on both upstream and downstream faces 10 ft. thick at the top, increasing to 90 ft. at the bottom. The resulting structure will raise the water at normal storage or spillway crest level about 100 ft. above the streambed. In maximum section the dam is about 1,000 ft. thick at the base. The accompanying cross-section (Fig. 3) indicates the slopes obtaining in the several zones.

An essential feature of the design is the location of the major bulk of the structure on the upstream side of the rock abutments or constriction of the canyon walls which form the dam site. The strategy of this plan is that in case the reservoir is full and the dam is saturated when a big earthquake comes, the gravel and rockfill blankets will hold the earth core in place and the latter will retain the stored water. In the event that the dam is stretched endways by an earthquake so as to open up a fissure in the structure, the gravel with heavy rock on top of it will fall into the cracks and prevent the water from rushing through. By virtue of its location immediately above the dam site abutments, even if the structure were badly shaken and cracked, the material would be pushed up against the abutments and could not slip or slide downstream.

The outlet structure beneath Coyote Dam was given a somewhat irregular alignment so that it might be wholly within a continuous block of solid rock which shows no shear zones. To prevent water pressure ever being held in the outlet pipe no valves were permitted on the lower end. Regulation is accomplished by butterfly valves hydraulically operated with controls on top of the dam.

In one of the exploration tunnels under the Coyote Dam site pebbles were encountered in one of the recent shear zones which are believed to have dropped 40 or 50 ft. from the surface, probably through an open crack. If cracking of this sort occurs again, this time beneath the dam, the force of gravity on the rockfill and gravel overlying the core is expected to function so as to close up such fissures automatically and immediately.

That such fissuring is neither imagi-

nary nor minor in character is indicated by an incident of the 1906 shock on the San Andreas fault. Where this fault passed through a dairy yard a fissure opened and subsequently closed after allowing a cow to drop into it entirely out of sight. Such a fracture beneath the Coyote Dam with the reservoir full, it is believed, would be closed safely before the water could rush through.

In California the design of dams has to be approved as to safety by the state engineer. On the design of the Coyote Dam, State Engineer Edward Hyatt had the advice and approval of George W. Hawley, deputy state engineer in charge of dams, and a consulting board consisting of Fred C. Hermann and J. D. Galloway, consulting engineers, and Prof. Geo. D. Lounderback, consulting geologist. The writer, in designing the dam as engineer for the district, had the advice of H. L. Haehl and the late George C. Elliott, consulting engineers, and Dr. C. H. Tolman, consulting geologist. H. I. Wood was construction engineer.

Reorganizing a Water Utility for More Efficient Service

Methods and policy as well as equipment are subject to depreciation, and departmental reforms are just as necessary as physical improvements

REORGANIZATION of the Denver municipal waterworks department which included revamping of basic managerial functions, the introduction of budgetary control and the utilization of more efficient office procedure was initiated recently to provide better service at lower cost. An outline of the experiences in making major changes of policy and method was presented by E. G. Plowman, former executive assistant to the Denver Board of Water Commissioners, at the Los Angeles meeting of the American Water Works Association on June 9.

The city of Denver first took over ownership of its water system in 1918 and since that time the questions and problems of physical betterment and extension to water plant have been paramount. In 1932 it was decided to direct attention to the internal improvement of office and operating practice.

In any reorganization, the first decision must be with respect to basic organization. In the Denver case, it was decided to rebuild the executive organization along functional lines because this type of organization meshes properly with the legal functionalization imposed by the charter, which has made the city auditor, treasurer, and attorney responsible for appropriate water utility work. It has also solved the vexing problem of preparation for and conduct of board meetings. The seven functional "managers," meeting as a committee, prepare the board meeting agenda. Operating problems are then submitted by the appropriate manager to the board in advance of the meeting. The functional "managers" attend the board meetings and stand ready to answer board inquiries concerning recommendations.

The second problem attacked was the budget. Transference to the city treasurer of debt service in twelve equal monthly installments, instead of waiting for peak payments in particular months, has simplified the general budget of monthly income vs. total expense. After three experimental budgets constructed in 1933 and 1934, the water department has operated, since early 1935, on a fully budgeted basis. Modeled in part on the form used by Dallas, Texas, the budget is carried out in detail by work type, expense classification, personnel required, and by months.

Billing and office routine

Adoption of the procedure of dividing the 65,000 schedule license bills into three equal parts, so that one-third of the quarterly bills are sent out each month has reduced the former peak loads on the billing group and on the cashiers. Another decision that might likewise seem to be over-emphasizing the obvious that gave good results, was to rearrange the office layout so that clerical workers were not watched and hailed by customers hunting for adjustment "shortcuts."

Billing, collecting and accounting were placed together, under one functional manager, and employees were specialized on typical jobs wherever possible. An afternoon and early evening shift of office employees was established to check receipts.

After much study, the punch card system of billing was adopted for the schedule bills, for the following reasons:

1. Once the master punched card record has been created, and matched with the addressograph plates, the customer must receive the correct bill, automatically adjusted for the added irrigation charges of the summer. The water board is able to audit its income, starting with the total amount on the schedule books, and accounting for all vacancy and other credits. Checking of receipts has become almost foolproof.

2. The punch card bill has made it possible to give the customer considerable detail concerning the actual billing base for his own premises.

Improvements have been made in control of inventory and shops. The accounting division has appointed a traveling representative, who checks the actual inventory at every operating point once a year. This has reduced the practice of charging out in excess of needs, and has returned much "charged-out" stock to regular inventory accounts. The inventory itself, and all shop operations performed by the water department have been concentrated, as far as possible, at one storage yard under one superintendent.

The daily expense distribution, including the payroll records, is now posted by machine, replacing former hand work. The punch card machine is beginning to take over mass production portions of the accounting load, such as the inventory records.

In 1933 there were no personnel records worthy of the name. Today the service record of every employee is available, along with detailed information of special character.

Nearly every employee has been transferred in one way or another, during the three years since 1933. This has reduced the bad effect of years of almost no labor turnover, as follows:

1. Old employees who had been blanketing key promotions of younger men stepped aside into less important work.

2. The new methodical pay classification was given the acid test of comparative ability of different individuals cross-transferred, each to the position of the other.

3. Many employees found new interest in their work, and developed multiple skill of value to the water department.

4. It became possible to concentrate the reduced "extra list" of part time day pay employees at two operating points.

Results of reorganization

This general program of reorganization has reduced Water Department operation costs as shown in the following tabulation:

Pumping Station Expense:
1932 ..$122,940.72
1935 .. 94,926.44 — Chief reason further electrification

Reservoir Expense:
1932 ..$ 94,370.96 — (year average, 1927-1931 $75,000)
1935..$ 53,935.38*
*due partly to reclassification, largely to fence building and less moss cutting

Motor vehicles expense:
1932 ..$ 59,360.59
1935 .. 29,767.53 — New standardized cars and pooling plan

Total expense:
1930 ..$779,889.33 1933 ..$711,601.30
1931 .. 775,714.88 1934 .. 738,920.13*
1932 .. 772,707.32 1935 .. 737,817.68*
*Budget for operation in both years—$740,000.00.

These savings have been absorbed in various ways, such as the following:

1. The working week has been reduced from about 44 to 40 hours.

2. A large number of merit increases in pay have been made. Service men, clerks, and other classifications have had a senior grade added.

3. All long service employees doing permanent work are now on the monthly payroll, thus giving 350 instead of 250 annual vacations with pay.

4. A formal sick-leave plan has been established for all monthly employees, costing about 1 per cent of payroll per year.

5. New debt service costs for completion of the Moffat Water Tunnel amount to about $15,000 monthly additional expense.

6. The unencumbered cash balance has risen from a small red figure in January, 1934, to over $500,000.

7. Much new work has been undertaken, such as valve checking; accounting controls; water waste inspection; special lawn irrigation enforcement inspectors; public relations bulletins and advertising. These latter activities were, in part, responsible for reducing 1935 average daily consumption to 153 gallons per capita—20 per cent under the previous 17 year average, and over 10 per cent under the previous lows in 1935 (176 gallons) and 1933 (177 gallons).

Railway Relocation in San Jose

THE SOUTHERN PACIFIC Railroad for many years has operated its main line through the downtown district of San Jose, Calif., with a considerable part of the route on city streets and without grade separations. San Jose is 47 miles south of San Francisco on the coast route to Los Angeles. Recently an entirely new location for the main line through the city has been completed and put in service. The project as a whole included 6 miles of new main line, an attractive passenger depot and nine grade separations. The total cost was about $3,250,000.

The new route leaves the old main line in the north end of San Jose and follows the old Santa Cruz branch line past a new passenger depot in the downtown district. South of the depot the new main line swings to the east of the Santa Cruz branch and with the aid of grade separations and private right-of-way avoids the hazards and traffic delays of the old route. At the south end of the city the new route was located through a hilly area where some 120,000 cu.yd. of excavation was involved.

For the most part underpasses for pedestrian and automobile traffic consist of rectangular reinforced concrete structures thoroughly damp-proofed on the outside and lighted within by electric lights. The roadway opening is 15x30 ft. in cross-section and two sidewalks 6 ft. wide are provided for pedestrians. The one overpass is the San Carlos St. viaduct which is an all-concrete structure 978 ft. long; its concrete deck is a series of skew bents carrying a 40-ft. vehicular roadway which includes a single street railway track. There also are two 4½-ft. sidewalks.

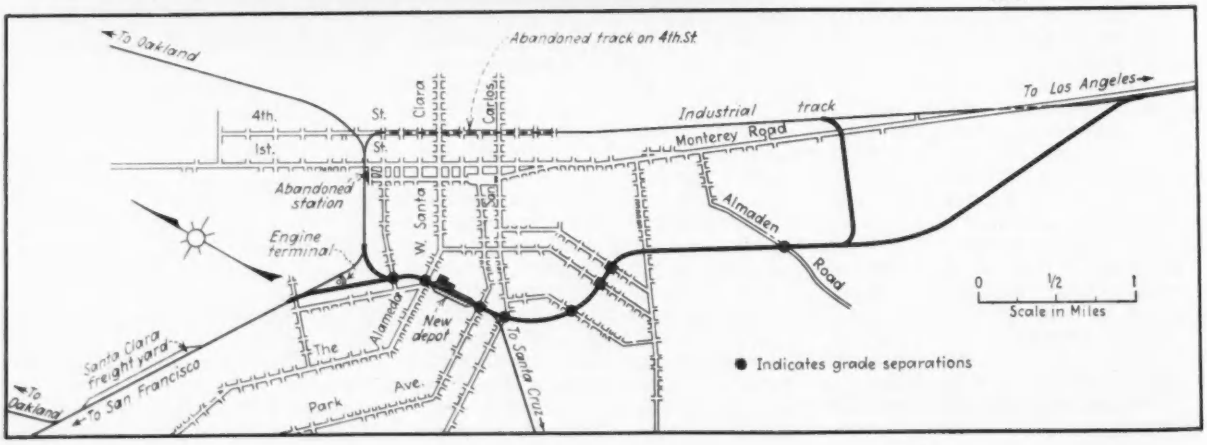
FIG. 1—TYPICAL OVERPASS with a 15x30-ft. roadway opening and two sidewalks.

The most objectionable part of the old main line, namely, more than a mile of trackage at grade along Fourth St., has been abandoned and the industrial district south of this area, formerly served by spurs from the old main line, now is served by the same spurs but access to them is from the main line at the south end instead of through the thickly settled Fourth St. district.

At the passenger depot four tracks are spaced to accommodate wide station platforms connecting with the station by ramps and a pedestrian subway. A separate track is provided for handling mail, baggage and express in carload lots and a bypass track entirely around the terminal yard permits freight trains to pass through without interference with the passenger trackage. Near the station are five sidings with capacity for storing 71 passenger coaches. This is used for the servicing and cleaning incidental to maintaining the heavy commutation service which runs through from San Francisco to San Jose.

The project was planned by and construction was carried on under the direction of W. H. Kirkbride, chief engineer, Southern Pacific Co. E. C. Morrison was construction engineer.

FIG. 2—OLD AND NEW locations of the Southern Pacific main line in San Jose, Calif.



Cities Without Water—II

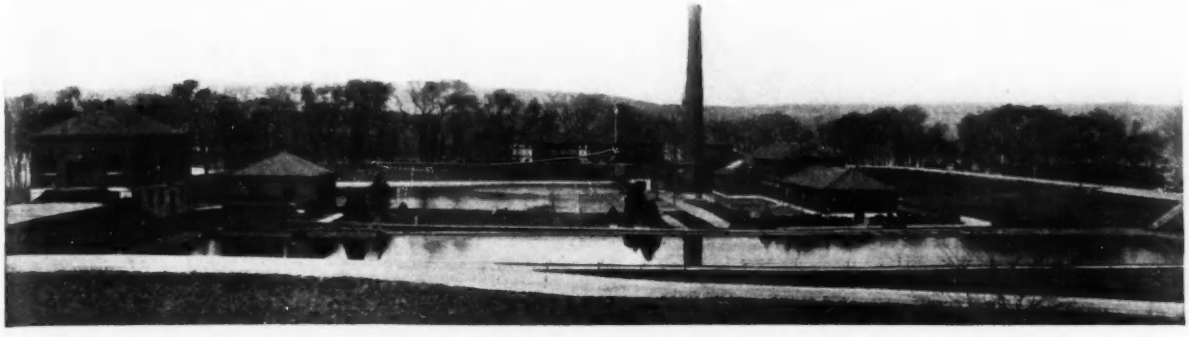


FIG. 1—BEFORE THE DELUGE, Harrisburg's water filtration plant, showing the protecting dike which was overtopped by the flood.

Harrisburg's Waterworks Failure During the Flood

By Chas. H. Kressler and Ralph W. Foster
Engineers with Gannett, Eastman & Fleming Harrisburg, Pa.

HARRISBURG, PA., went through the tribulations of a water famine during the recent record flood of the Susquehanna River, which put pumping and filter plants out of operation. Only by restricting water use to drinking and sanitary purposes, and by securing supplies from outside sources, was the city able to meet the emergency. The story of the failure of the Harrisburg waterworks and the resulting enlistment of outside aid is told by two engineers closely associated with the emergency operations. This is the second of two articles on large city waterworks failure during times of flood; the first, depicting Pittsburgh's experience, was published last week.
—EDITOR.

ADJOINING water systems, nearly all of which are privately owned, furnished sufficient water to prevent a complete breakdown of Harrisburg's municipal supply when the city's filter and pumping plants were put out of commission during the Susquehanna River flood of Mar. 18-19. While the city was never completely without water, it subsisted on emergency water rations for several days. By the time service was restored the situation was desperate. Water was doled out by the cupful, and a serious fire would have found the city virtually helpless.

The Harrisburg flood was the highest on record, reaching a stage of 30.33 ft. at 6 p.m., Mar. 19, thus exceeding by over 3 ft. the previous record of 27 ft. established in 1889. Heavy rains falling on ground saturated from melting snow over the entire watershed caused the flood. The combined crests of the West and North branches of the Susquehanna, meeting at Sunbury and rushing down the valley to meet the high level of the Juniata, which enters the Susquehanna above Harrisburg, resulted in the unprecedented high water at the city.

The municipal waterworks consists of river intake, a filtration plant and a low-lift pumping unit all located on City Island in the middle of the Susquehanna River, a high-lift pumping station on the Harrisburg shore, and three reservoirs that feed a gravity supply system. The vulnerability of the island location made necessary a protecting earth dike enclosing the entire filter plant. This dike was built in 1904 from designs by the late James H. Fuertes, for a river stage of 30 ft., which was then considered adequate. A 42-in. gravity line, under the river, carries the water from the filter plant to the high lift pumping station on the Harrisburg bank of the river, from which the water is pumped to city reservoirs.

The high lift station was not protected against a river stage above 22 ft., and early on the forenoon of Mar. 18, an attempt was made to gain an additional 3 ft. of protection by building a sandbag dike. Rising waters overtopped this dike at 8:10 p.m., rendering the high lift pumping station inoperative. From then on the city was dependent upon the storage in the reservoirs, together with any outside sources available.

Just before the water broke over the dike at the pump station, orders were given to shut down the plant. It took until 9 p.m. to pull the fires, shut the valve on the 42-in. gravity line from the filter plant, stop the pumping unit, shut off the oil lines, stop the oil pumps and sewer pumps, and remove the records. Seven men took care of this work. In the meantime, a crew of electricians attempted to remove the motor from the 5 m.g.d. auxiliary unit and get it to high ground. The water rose so fast in the pump room that these efforts were only partly successful. The flood waters at their height covered the lower 18 in. of the unit.

When the filter plant operators learned that the pumping station was to be shut down they closed the intake valves and sluice gates on the raw water well. One raw water engine-driven pump was kept in operation, pumping infiltration through the dike into the sedimentation basins which had purposely been kept 3 ft. below the normal operating level. Part of the leakage went into the sewer well and was pumped into the river. The clear well was flushed at intervals into the sewer well. As water in the sedimentation basins rose, a 14-in. filter supply valve and a waste valve were opened to discharge in the sewer well. The total leakage being pumped to the river was about 2,600 g.p.m. There were seven men on duty at the plant during this period.

The dike was finally overtopped at 8:40 a.m., the piling up of the water, due to high current velocity and a 35-mile gale, causing the overflow before the 30-ft. river stage, for which the dike was designed, had been reached. The crew had been taken out at 7 a.m., after having drawn the fires, shut down the pumps and pulled the switches.

The three city reservoirs are on high ground 1½ miles east of the high lift pumping station. They have a combined capacity of 50 m.g. The reservoirs were practically full when pumping was stopped. By 9 a.m. on Mar. 19 the total storage had dropped to 44 m.g. At the normal consumption rate of 10 m.g.d., this was sufficient supply for only 4½ days. The flood crest had still not been reached and it was realized that with both the pumping station and filtration plant under water, Harrisburg faced a grave water shortage and

every possible method of conservation must be employed.

The consumption, including leakage, during the 24-hour period ending at 9 a.m. on March 20 was 9.8 m.g. This was alarming in view of the relatively small storage and made stringent regulations as to use of water necessary.

Mayor John A. F. Hall and William T. DeHart, director of public safety, ordered all business places, industrial plants and factories using large quantities of water closed until the water shortage was over. Specific reference was made to laundries, beauty and barber shops, cleaners, garages, cleaning houses, breweries, soft drink establishments, and like commercial operations. Restaurants and hotels were ordered not to serve water unless asked for, and then limit the amount to one glass per person. Tap rooms and light lunch establishments were ordered to use paper cups and dishes to avoid dish washing. In many cases employees of the city water department actually shut off the water services where these orders were not obeyed. Generally, however, the public met the crisis with good-natured cooperation.

On Mar. 20, the Harrisburg Suburban Water Co., which supplies suburban territory to the east, offered to transport to the city a minimum of 800,000 g.p.d. through its connecting mains from the Hummelstown Consolidated Water Co., owned by the Pennsylvania Power & Light Co., and located 8 miles east of Harrisburg. This service began at 1:00 p.m. on the 20th and continued until 10:30 a.m. on Mar. 31. During the emergency over 10 m.g. were supplied. The Hummelstown supply, which is obtained from Swatara Creek at Hummelstown, is filtered. Connections are maintained at all times between the Harrisburg suburban mains and the city mains for interchange of water when necessary. In this emergency the Chambers Hill reservoir of the Harrisburg Suburban Water Co. was shut off, and the Hummelstown pumps were operated against the pressure of the city's high level network. Through a 12-in. main supply line of the Harrisburg Suburban Co., Hummelstown was able to pump between 850,000 and 1,000,000 g.p.d. to Harrisburg, in addition to supplying the company's consumers. Arrangements for obtaining this supply were made by F. H. Eastman, president of the Harrisburg Suburban Water Co.

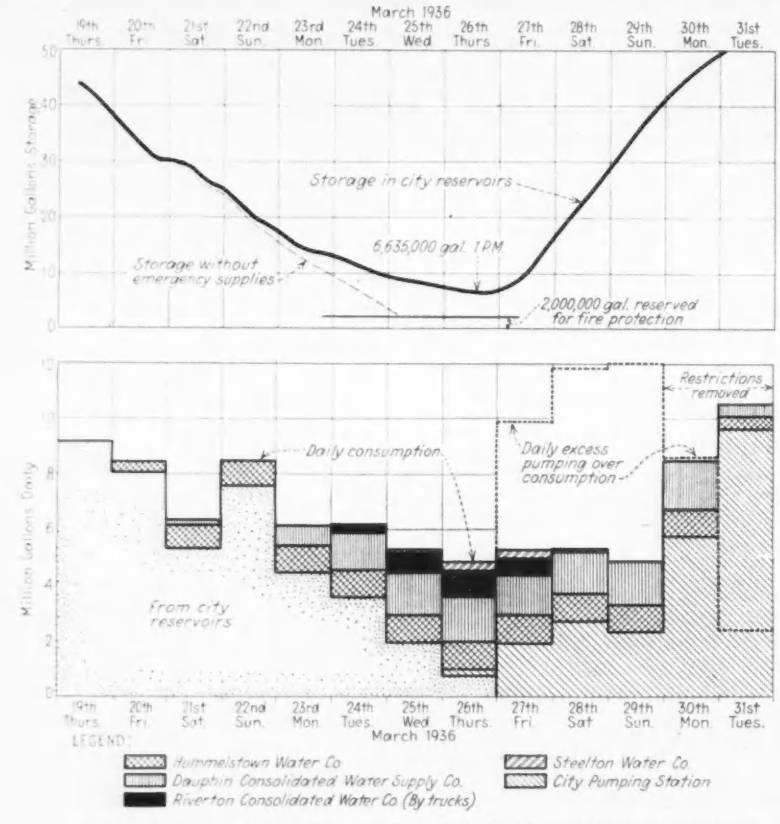


FIG. 2—RESERVOIR STORAGE and daily consumption of water during the emergency flood period. The shaded areas show how dependent the city was upon outside sources.

Another privately owned company coming to the city's aid was the Dauphin Consolidated Water Supply Co., owned by the Pennsylvania R.R., which furnishes filtered water to domestic and industrial consumers in the borough of Dauphin and along the east side of the Susquehanna River north of Harrisburg, between Dauphin and the city limits, a distance of 8 miles. It also supplies unfiltered, but chlorinated, water to the Pennsylvania R.R. shops and yards in Harrisburg and to Enola, situated on the west shore of the river.

Water is obtained from Stony Creek, a mountain stream having 38 sq.mi. of drainage area and entering the Susquehanna at Dauphin. The company's pumping station is located on the bank of the Susquehanna, and on Mar. 19 water came within a few inches of overtopping the filters, clear well and pump room, but was held out by sand bagging.

The domestic service, including filters and pumps, has a capacity of 300,000 g.p.d. and a storage capacity of 165,000 gal. This supply was turned into the Harrisburg mains on Mar. 21, but so crippled the company's own domestic supply as to make that arrangement impracticable.

The railroad supply is furnished by a 5 m.g.d. motor-driven pump, with a 4 m.g.d. unit as a spare. There is also additional pumping capacity of 1 m.g. from two water-turbine driven pumps, but these units were inundated and out of service at the time of high water. The railroad supply has a storage of 2 m.g. in a steel standpipe at Dauphin and a 3 m.g. reservoir at Enola.

The supply lines for this unfiltered supply consists of a 24-in. main from Dauphin to the Harrisburg railroad shops, a 16-in. line across the Susquehanna River at Rockville, and a 20-in. main down the west shore to the Enola shops. The pumping pressure at Dauphin is 75 lb., being limited by the elevation of the open steel standpipe; and the pressure at the Harrisburg shops is normally from 50 to 65 lb. Emergency metered connections, two 8-in. and one 6-in., tie the railroad supply system and the Harrisburg city system.

Normal pumpage for railroad use is 4 m.g.d. In order to supply as much water as possible to the city, the railroad consumption was restricted and in addition, an abandoned pumping station on the west bank of the river at Enola was put in service to pump raw water to an elevated steel tank supplying locomotives. This emergency station was one of the most interesting side lights on Harrisburg's emergency supply. It included intake works at the river end, and three reciprocal steam pumps, having a total capacity of 2 m.g.d. The boilers for this old station had been dismantled, and in order to furnish steam a locomotive and a crane for coaling it were put in service.

Due to the difference in pressure between the city and railroad supply, a shutoff area was carried by the Dauphin Co. This service began on Mar. 23 and continued until Mar. 31. Consumption for this area averaged 1.6 m.g.d., the daytime rate from 2 to 2½ m.g.d. The line supplying the Enola shops was shut off during the day to keep up the Harrisburg pressure. During each night the Enola reservoir was filled. Over 12,000,000 gal. were supplied by the Dauphin Consolidated Water Supply Co. during this emergency period. The area served, entirely domestic, was 1.9 sq.mi. and contained 8,800 of the city's 19,000 domestic consumers.

The condition of the Stony Creek water at Dauphin and in the mains was constantly supervised by the state health department, as this was the only unfiltered water entering the city's mains. The condition was pronounced excellent at all times. Two chlorinators were in service on the 24-in. line, and the water was heavily chlorinated. The chlorine residual was betwen 0.5 and 0.8 p.p.m. at the plant, was high at Rockville, and some residual was always found in Harrisburg. To provide for storm conditions, two high capacity tubes were available for use on the chlorinators and a large chlorinator was obtained from the Hershey Chocolate Co. However, none of this emergency equipment was used.

Arrangements for this emergency supply to Harrisburg were made by the Pennsylvania R.R. under the direction of J. A. Russell, manager of water service, Raymond Swenk, general superintendent, and William S. Gibson, assistant engineer for the P.R.R. water companies.

The Riverton Consolidated Water Co. serves the West Shore boroughs of New Cumberland, Lemoyne and Camp Hill, with a filtered supply obtained from the Yellow Breeches Creek. Although no physical connection exists between the Riverton mains and the Harrisburg city mains, the company offered through its manager, W. L. Eisert, to supply water to the city if a pipe line could be laid on one of the bridges crossing the Susquehanna.

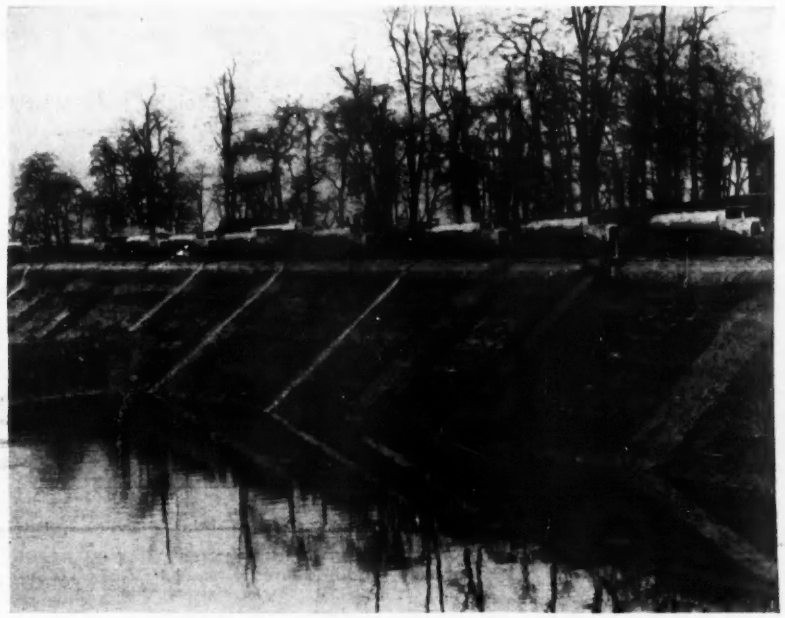


FIG. 3—DRIBBLES OF WATER from a fleet of gasoline trucks discharging into an almost-empty reservoir helped to stave off a water famine in Harrisburg.

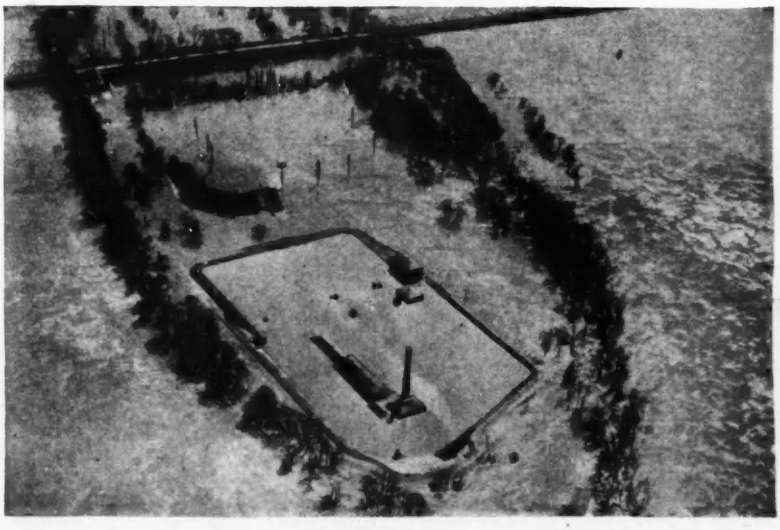
While this was being considered, G. W. Lawrie, manager of transportation for the Atlantic Refining Co., offered to the city the use of a fleet of 50 Atlantic tank trucks and drivers to haul water from any source the city might designate. The city accepted this offer, and hauling began on Monday evening, Mar. 23. The trucks were returning from Pittsburgh where they had been likewise assisting during a water shortage. On Tuesday 50 relief drivers were sent by the Atlantic Co. from Philadelphia, and hauling continued 24 hr. a day until 9 p.m. Friday.

The trucks, of 1,200 to 2,000 gal. capacity each, hauled 2,100 loads to the reservoirs. Most of the water was obtained from hydrants in Lemoyne, where trucks could be loaded in 5 min. Some fifteen loads were hauled the first night from Hershey, Pa., but this source was discontinued because of the great distance, a 28-mile round trip as compared with an 8-mile round trip haul from Lemoyne. On Wednesday afternoon two Hershey Creamery trucks joined the Atlantic fleet and continued through the remainder of the emergency. A number of truck loads were hauled from the Pennsylvania Dairies' supply, but the filling time at this source limited its use. The unloading time for trucks at the reservoirs was 15 min., and a complete round trip required on the average one hour. A total of 2,750,000 gal. was hauled by truck.

Military police patrolled the entire route to give the trucks right of way over all other traffic. The high speed maintained by the trucks and the continuity of their hauling was not only an interesting sight to the average citizen but probably did more than anything else to bring to his attention the seriousness of the water situation.

From noon Mar. 25, to 7 a.m., Mar. 28, Steelton Borough helped to carry the city load. This was done at its own hazard, as its plants had been put out of service for a short time by the flood.

FIG. 4—WATERWORKS IN DISTRESS, an aerial view of the same water filtration plant shown in Fig. 1, after the Susquehanna River had dropped 3 ft. from its record flood crest.



Although the plant was reconditioned very promptly the reservoirs had not had an opportunity to refill for use in case of fire.

This was the first time that the Steelton plant had been put out of service by flooding. Infiltration and seepage inundated the clear water wells, while the slow sand beds and pre-filters were also flooded. When the flood receded a fire pumper was used to pump water back through a flush pipe to the filter. This water, after being overdosed with chlorine, was put through the ordinary filtration process. Chlorine was also applied directly to the slow sand beds. By this process the plant was effectively sterilized and kept in condition to filter when the water could be obtained from the pumping station, which also was flooded. Sterilization was continued as long as water could be obtained from the river by pumper and saved two days' time when pumping was started. As no physical connection exists between the Steelton and Harrisburg lines, two lines of 2½-in. fire hose were put into service between hydrants, 1,360 ft. apart. The pressure differential was not sufficient to send more than 50 or 60 g.p.m. through each line. After six hours' operation a pumper was hooked in the connecting lines, and the boosting by the pumper resulted in increasing the amount sent into the Harrisburg mains to 100 to 120 g.p.m. through each line, or a total rate of about 325,000 g.p.d.

Precautions against typhoid

To prevent an outbreak of typhoid or other water-borne diseases, residents of the city were ordered to boil all drinking water at least 30 min. Although the only unfiltered supply to the city was from the Dauphin Consolidated Water Co., there was danger after the city's pumping station and filter plant resumed operation, of some contaminated water remaining in the system. Normally, a complete cycle for the water from river to consumer requires two days. In the emergency period of outside assistance, up to Mar. 31, a five-day cycle was allowed, after which two-day samples were tested. As these showed no contamination the boiling requirement was removed on Apr. 6.

In addition to boiling water, all residents were requested to be inoculated against typhoid. Some 30,000 individuals acted on the recommendation, 5,000 being inoculated free by the city's board of health, and the remainder were treated by hospitals and private doctors.

The city water department's laboratory, in charge of Dr. George F. Moffitt, and G. N. Book, ordinarily run tests on seven samples of water per day. During the emergency, as many as 75 samples were tested daily. Many of these were samples from auxiliary wells and supplies of individuals, dairies, etc., who desired to make use of local supplies during the emergency. Included also were tests of the water supplied by the adjoining water systems. In addition, five milk samples were tested each day in order to immediately detect any trouble from that source. To carry on this work Mr. Book went to the filter plant laboratory by boat and removed such equipment as he could still use and set up a temporary laboratory at the Harrisburg Hospital.

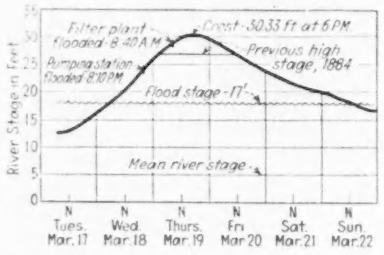


FIG. 2—RISE AND FALL of the Susquehanna River at Harrisburg during the all-time record flood.

By noon, Mar. 21, the river stage had receded sufficiently to permit starting work on a temporary roadway from the island end of the Walnut Street Bridge to the filter plant. This work was held up temporarily by the weakened condition of one of the bridge piers, though permission was finally granted for light trucks carrying ashes to cross the bridge. In the meantime, the city highway department was collecting logs and other debris washed down by the flood water to fill up deep wash holes.

Arriving at the filter plant by boat, a crew of laborers immediately started cutting a hole in the earth dike. This hole was completed, by digging and blasting, 4 p.m. Saturday, March 21, and the water level within the dike inclosure dropped 7 ft. by Sunday morning, allowing employees, traveling in boats, to enter the head house.

It must be kept in mind that before the dikes were opened there was about 10 m.g. of water inside the diked inclosure, and 3 in. of mud everywhere. Most of the coal in storage had been washed into the low lift pump station.

The main hole cut in the east side of the dike was opened at 10 a.m. Monday, Mar. 23, and by 7 a.m., the next day the water had dropped below the filter plant floor. The last 6 in. of water here had to be removed by pumping.

Some 800 tons of barley coal had been washed into the boiler and engine rooms and the condenser pit; coal was piled 6 ft. deep against the outside of the boiler and engine rooms.

Entrance was gained to the boiler room at 8 a.m. Mar. 24. The boilers and settings were inspected, the mud washed out, and slow-drying fires started at 4 p.m. Meanwhile, three fire pumps and gasoline-engine-driven pumps were removing water from the engine room.

The engine room was first entered at 9 a.m. Mar. 25, and by 4 p.m. of that day the boilers were carrying 110 lb. of steam pressure, and one raw water engine pump, one sewer engine pump and one wash water engine pump were in slow motion, running non-condensing, as the condenser pit was still full of coal and water. That same day the filter room was washed out and the filters drained, and by 11 p.m. all filters were scraped and lined. At 10 a.m. on the 26th the filters were filled with water and at 10.50 a.m. the effluents were opened. An examination of the clear well showed very little sediment, and the plant was placed in operation, with the exception of the air wash engine, at 2 p.m.

By Mar. 28 all pumping units had been reconditioned except one of the two spare units that had been completely covered with coal. A day later the condenser pit was cleaned and the condensers were put in service.

While the filter plant was being rehabilitated, similar work was taking place at the high lift pumping station. The flood waters, at their height, had been 8 ft. 2 in. deep in the boiler room, and 15 ft. 1 in. deep in the engine and pump room. Entrance was gained to the boiler room at 8 a.m. on Mar. 21. The room was washed out, raw water being obtained from the river. Slow drying fires were started at 3 p.m. The engine room was first entered at noon the following day, and by night a crew of mechanics started tearing down one of the main 15-m.g.d. pumping units and cleaning mud and sand from the bearings and interior. Tuesday morning a representative of the Allis-Chalmers Co. arrived to assist with the work, and this unit was ready to put in operation by 2 p.m. Mar. 26.

State and city health officials at that time decided to open the 42-in. gravity line from the filter plant and pump the water to waste. Subsequently, the reconditioned unit was put into operation at a rate of 8 m.g.d., and samples were taken every 15 min. to determine the turbidity. Shortly before 9 p.m. on Mar. 26 the turbidity was down to zero. The pump was then shut down, the system valving changed, and before midnight pumping was resumed, the water being pumped into the high service reservoir at a rate of 9 m.g.d. Rehabilitation of the second main pumping unit was started on the 27th, and was put in operation by the 30th.

Geo. W. H. Roberts is chief engineer of the Harrisburg Water Department. Gannett, Eastman & Fleming, consulting engineers of Harrisburg, were called in to assist in the emergency and rehabilitation work.

REGULATING TRANSPORT—IV

Fool Laws Ride Road Transport

By John S. Worley
Professor of Transportation Engineering, University of Michigan, Ann Arbor, Mich.

BUS TRANSPORTATION of passengers and truck haulage of goods for hire are the only motor-vehicle operations that come within regulation of transport as it is considered here. Applying the principles of regulation previously enunciated neither truck nor bus traffic presents any alarming problem. Indeed it could be said that present regulatory measures are sufficient and some of them promise to serve no good purpose.

With the development of the automobile and the present highway system came a new carrier business by which both goods and passengers are being transported. In the goods business are common carriers and a group of private haulers for hire who may be classified as quasi-common carriers. There is also included the carrying of passengers for hire by motor buses. These developments have been possible and can continue to exist only because they are able to render a service more satisfactory and more economical than other forms of transportation and when they are no longer able to do this they will go out of existence.

It has been asserted that this particular type of carrier has entered and continued business only because it has the free, or practically free, use of the highways. The most that can be said at the moment is that some studies have been made of this charge most of which are quite superficial, and some of which have the earmarks of not seeking a correct answer. This is a subject of which intensive studies should be made so that a more positive conclusion can be reached.

Legislation analyzed

1. Railroad sponsored federal control has not benefitted railways, motor transport or the public.

Motor Bus Transport — The gross revenue of intercity motor bus transportation in the United States for the year of 1934 was $171,200,000 while the gross revenue for railway passengers amounted to $329,342,000; the gross revenues for intercity bus transportation being about 50 per cent of that of rail transportation. There is no information as to how much of the bus transportation is interstate and how much is intrastate.

The motor bus furnishes a more frequent service to many communities which before had only occasional service, regular service to inland towns and villages which before had no regular services, and the only service to persons living between population centers where no service existed before.

Automotive bus companies engaged in transporting passengers over regular routes, are meticulous in having their vehicles observe published schedules, for it is through prompt service, with other advantages which they offer, that they are able to build up and maintain their businesses. The comforts which they offer to their passengers appear to be entirely in keeping with the fares charged as there have been few, or no, complaints. As a rule bus companies operating over regular routes are doing so under certificates of convenience and necessity, which, in a large degree protects them from other motor bus competitors. This is particularly true in intrastate operation. There are instances where motor-bus operators do make complaints with reference to the rate reductions by their competitors, other motor bus companies, the railways, and waterways, and so ask for protection against reduction in rates. With the protection which they now have through certificates of convenience and necessity it would appear questionable that they should be guaranteed against competition, but there may be certain specific instances when this might be desirable.

In most of the states the public utility commissions are regulating motor-bus corporations in the matter of rates, security issues, compensation insurance, carrier insurance, and adequate safety requirements. While these relate solely to intrastate operations, they, in a large degree, affect interstate operations. As has already been pointed out, in general, there have been no complaints by the public about motor bus operations and little or no ground for the belief that further regulation of either intra or interstate operations are required in the public interest.

In the light of the above, it seems strange that Congress should enact motor-vehicle regulations, which it did in its recent Senate Bill 1629. In the debate before Congress, preliminary to the passage of this act it was pointed out that at the hearings before the House or Senate committees no shippers or shippers' interests or passengers or persons representing the public interest had appeared before the committees and testified for and recommended the passage of this bill. It was further stated that the bill was largely sponsored by the railroads with support from certain bus and motor truck associations.

It is true that legislation specifying the length, width, height of motor vehicles operating in interstate commerce would have been to the advantage of both the operators and the public; however, congress failed to pass any such law, only placing upon the Interstate Commerce Commission a mandate to study this subject and make recommendations as to future legislation.

A careful study of benefits which may come to motor-bus corporations through the operation of Senate Bill 1629 furnishes no evidence that would lead one to consider them at all certain. It is true that, should the Interstate Commerce Commission refrain from issuing any additional certificates those companies engaged in interstate operations will acquire a quasi-monopoly of the motor-bus business over the routes which they are privileged to operate but this will in no way relieve them of the competition of other forms of transportation. Should the Interstate Commerce Commission decide to equalize rates between various carriers as has been frequently intimated it would do, then motor bus rates will be increased and motor bus operations will be affected thereby. This increase in rates, however, will be at the expense of the riders. The increase of motor bus rates, where the increase is essential so that the properties be self-supporting, cannot be questioned and should be made, but the increase of motor-bus rates that other transportation agencies may compete for the business would not appear to be in the public interest or to the advantage of motor-bus companies.

It is possible that a pecuniary benefit might come to motor-bus operators through the sale of their properties to the railroads, which action would very largely create a railway monopoly in interstate passenger transportation. Whether such a monopoly would be in the public interest or not can only be determined after it has been in operation for a considerable time; the general feeling of the American public, of course, is against any such monopoly.

Truck Transport — Intercity motor-truck transportation for hire in the United States in ton miles is a very small part of the total intercity freight transportation, being less than 2.5 per cent. Of this amount, less than 0.6 per cent is interstate business, of which less than 0.25 per cent is common-carrier business, and less than 0.35 per cent is

contract-carrier business. The figures above are for the year 1932; the year 1935 will probably vary but little from 1932.

The charge for this service varies but slightly from the published rate of the railways, however, in many instances it is cheaper since truck charges include pick up and delivery cost at the terminals while the published railway charge includes only railway transportation and not the cost of pick up and delivery. There has been no complaint by shippers that the charges for motor-truck transportation have been excessive or unreasonable.

In addition to any values which may arise through the savings in freight charges, motor-truck service has become of great importance to merchants and others by making it possible for them to reduce their inventories and thus sell their goods on a much closer margin of profit. It has made it possible to have newer and fresher goods on the shelves and counters of retail stores; it has made it possible to put vegetables on the market within a few hours after they are gathered from the field, and it has made it possible for fruits to be transported longer distances so that they may be available within 24 hours after gathering. In the milk industry truck service has been of great importance to the public because the area over which the dairying industry can be carried on profitably has been greatly extended and milk is quickly gathered from its source and delivered to central points for conversion and delivery earlier and in much better condition than formerly. The services rendered by motor-truck operators is satisfactory to the shippers; a recent survey among a large number of small merchants in Michigan disclosed few or no complaints.

In most states motor-truck operators for hire are required to obtain certificates of convenience and necessity. The length, width and height of vehicles, their axle loadings, speeds of operation, brake equipment, and safety devices, as a rule, all come under the control of various state commissions who require the publication of rates and the making of annual reports of operations. The rates established and charged by all common carriers generally are subject to the approval of the public utilities commissions and in many instances the rates of contract carriers are under state public utility supervision.

Senate Bill 1629, which was passed in August of last year, has placed the regulation of all interstate motor-truck operators for hire under the jurisdiction of the Interstate Commerce Commission. This jurisdiction is complete with reference to all business phases of the operation but in the matter of the length, width, and height of vehicles, axle loadings, and similar matters, the commission is instructed to make a recommendation as to what law should be enacted on this subject. That there will be any public benefit in the regulation of the business phases of the interstate for hire motor-truck operations is to be questioned. In the hearings before the congressional committees, the suggestion was frequent that there should be an equalization of regulation, which includes equalization of the rates. If there is an equalization of these rates it may be to the slight benefit of motor truck operators but will certainly tend to increase the cost to the public.

The only thing that is needed in the matter of regulation of interstate motor truck operators for hire is a uniform code with reference to length, width and height, axle loadings, brakes and safety devices. It is unfortunate that Congress did not pass such a law or give to the Interstate Commerce Commission authority to establish such regulations. Had such a uniform law been passed, its enforcement could have been by the states.

Any benefit which will arise to the public through the regulation of the business phases of interstate motor truck transportation for hire, seems to be doubtful in light of the small amount of business compared with the total freight business of the United States and in light of the cost of administration by federal government.

In the matter of types of vehicles using the highways, it is possible that certain ones might, in the public interest, be denied the privilege of use.

Burdened by laws

2. Regulation has saddled road transport with two useless laws.

Under Senate Bill 1629 motor transportation companies cannot escape the destructive effect of regulation. As soon as regulatory measures begin to assume directional and managerial aspects great harm is done; there is built up in the minds of the executives and operators the idea that the government is responsible for the welfare and prosperity of the company and the executives turn to the government asking for legislation as a cure to all of their troubles. Instead, the government should enact legislation that gives executives the utmost freedom to attack and solve their internal problems; to seek a solution through legislative enactments can only lead to failure.

The philosophy that the government is responsible for the condition of our railroads and the asking by the executives for legislation to cure their internal ills is probably the most serious aspect of railway operation today. The railway problem will not be solved until railway executives cease seeking a solution through legislation, assuming full responsibility for their difficulties and proceed vigorously to correct these evils through their own efforts.

The motor-transportation corporations are now coming under full regulation as applied to the railroads, for which regulation there seems to be little or no warrant. It is to be hoped that their executives may maintain the progressive character which they now possess, continue vigorously to operate their properties and never seek a solution to their internal difficulties through legislative enactments, for if they do we may expect to find them in the same difficulties now being experienced by the railroads.

In November, 1933, at a special session of the Kansas legislature, there was enacted the Port of Entry Law, which went into effect on Jan. 1, 1934. The law has specifically to do with motor trucks of other states entering the state of Kansas. The law provides for very thorough inspection of all vehicles to determine the safety of their operation on the highways in Kansas. It provides that all carrier trucks must be protected with ample liability and property damage insurance. Upon entering the state, a complete statement for all vehicles is required as to ownership, make of vehicle, state identification, insurance carried, weight of cargo, its origin and destination, with original manifest covering the goods transported. Foreign vehicles entering the state of Kansas under the law have the privilege of paying the full Kansas license or registration fee the same as any other Kansas vehicle with the additional ton-mile tax. The general purpose of the law is to require all foreign vehicles to pay approximately the same tax as Kansas registered vehicles pay. There are certain exemptions to the law.

A study of the law at the time it was enacted, pointed to the conclusion that while there was a special advantage to the state of Kansas, this advantage would not be held for a period longer than two or three years because all surrounding states would enact similar port of entry laws in retaliation. This prediction has come true. The states of Missouri, Nebraska, Oklahoma, and Colorado have enacted port of entry laws, during the present year. As soon as these laws were enacted in retaliation to the one in Kansas, of course, all special advantages the state of Kansas gained have been lost and now the port of entry law becomes nothing but an expense to the state.

During this present year Delaware enacted a port of entry law.

As to how far this form of worthless regulation will spread cannot be predicted but it would seem reasonable to suppose that unless the port of entry laws are repealed it will only be a short time until practically all of the states in the union will find it necessary to enact them and carry out their administration at heavy expense as retaliation against adjoining states. All of this expense could be avoided by some form of legal reciprocity

Soil Mechanics Formally Accredited

Five days conference of 200 delegates from a score of nations brings forth an exceptional volume of recorded data and analysis of soil action and definitely puts the new science among the major resources of modern engineering.

CONVINCING TESTIMONY of the growth of soil mechanics as a factor in engineering practice was furnished by the International Conference on Soil Mechanics and Foundation Engineering held last week at Harvard University. Called together as a part of the tercentenary celebration of the founding of the university, the conference assembled some 200 participating members from a score of foreign countries and the United States. Over 150 papers were contributed as a part of the proceedings, which occupied four days of formal sessions and one day of inspection trips and closing addresses. A remarkably full attendance of members was had at all of the half score of sessions, and keen interest was shown in all the well organized proceedings. Incidentally, it requires notice that all papers and discussions were in English, all the speakers from foreign-language nations had a command of clear English which gave listeners full understanding and appreciation of their contributions to the conference proceedings.

Many papers considered

The large number of papers contributed (156 by count) precluded presentation in session; instead abstracts were printed in advance in two large volumes, aggregating nearly 700 pages. They were considered in discussion without oral presentation. For this purpose the papers were classified in 15 groups: (a) soil laboratories and testing apparatus, (b) soil sampling, (c) regional soil surveys, (d) soil properties, (e) stress distribution, (f) settlement of structures, (g) stability of earth works and natural slopes, (h) bearing capacity of piles, (i) pile loading tests, (j) earth pressure on walls, (k) groundwater movement, (l) frost action in soils, (m) stabilizing and compacting soils, (n) design and construction of foundations, and (z) miscellaneous. Much of the discussion centered on theory and mathematical proof, and therefore is not adapted to brief report in this place. Practical discussion was largely confined to foundation settlement, pile bearing capacity and pile loading, and methods of improving the physical properties of soils stabilizing them for construction purposes.

A number of illustrated lectures on current great earthworks added materially to the value of the conference deliberations. These included motion pictures on soil testing procedures and construction methods for the dams of the Muskingum Valley Flood Protection works, Fort Peck dam and the Quabbin dike.

Reviewing the development of soil mechanics as the science exists, Dr. Karl Terzaghi, of the Technische Hochschule, Vienna, Austria, and during the past semester visiting lecturer at Harvard University, president of the conference, in his opening address traced its origin, growth and achievements, and indicated that the conflict between theory and reality is coming to a period of rationalized observation. Ten years ago, Dr. Terzaghi said, the investigation of the mechanics of soil had the character of a professional adventure with rather uncertain prospects of success. This adventure began some years before the war somewhat simultaneously in Sweden, Germany and the United States. All of these early efforts had the important intention to establish a science comparable to the science of bridge design. Engineers looked forward to the development of laws and rules such as they were accustomed to apply when dealing with comparatively simple materials like steel and concrete. Today the last remnants of this unwarranted expectation exist in attempts to prescribe simple formulas for computing building settlement or piping in dams. No such formulas can possibly be obtained except by ignoring a considerable number of vital factors.

After a decade of experimentation, then, it becomes obvious that the method of approach must be radically changed. First, earth is never uniform; second, its properties are too complex for vigorous theoretical treatment, and third, mathematical solution is extremely difficult. Thus, in soil mechanics the accuracy of computed results never exceeds that of a crude estimate, and the principal function of theory is teaching how and what to observe in the field. Owing to these facts successful work in soil mechanics requires not only a thorough grounding in theory combined with an open eye for the possible sources of error, but an amount of observation in the field far in excess of anything attempted by the preceding generation of engineers. The center of gravity of research has shifted from the study and the laboratory into the construction camp.

As a result of this change there is noted a vast improvement in the quantity and quality of observation on full-size structures; rapid decrease in the antagonism between theory and practice, and replacement of blind faith in rules and prescriptions by a demand for evidence. Old theories will be superseded by better ones, but the results of conscientious observation in the field will remain as a permanent asset.

The skeptical attitude toward our conceptions and the readiness to modify them with increasing knowledge of the material must be considered the outstanding achievement of soils mechanics. We have learned to discriminate between what we really know and what we have merely believed. But the amount of knowledge sustained by adequate evidence is appallingly modest and the number of factors with a decisive influence on soil behavior is very much greater than was anticipated. Severe restrictions on further progress along purely theoretical lines have also become obvious. For example, theory demonstrates that arching develops in soils behind the timbering in cuts. It discloses the mechanics of arching and reveals the limits between which the distribution of the lateral pressure of the earth may range. At the same time it leaves no doubt that the real distribution of the pressure depends on the method of constructing the timbering. Since we are not in a position to evaluate this influence on the basis of abstract reasoning, we are obliged to secure the required information by direct measurement of the pressure in full-size cuts. A similar situation is faced in almost every other field of soil mechanics.

To summarize briefly: Our advanced knowledge of the mechanics and physics of soils makes it possible to grasp most of the essential factors that govern the stress and strain and the equilibrium of earth. It has brought a realization of the extremely narrow limits of the validity of the older theories and informs us of the existence of sources of danger which previously were hardly suspected. But to make the step from the qualitative appreciation of what is going to occur to a quantitative forecast requires accurate and systematic observations on full-size structures.

New foundation practices

Applications of new and ingenious methods of foundation practices were described in four papers on the San Francisco-Oakland Bay Bridge, on a series of large bridges and bridge projects in Denmark, on harbor works in Bremen, Germany, and on foundation work for a heavy building in Lugano, Italy. The paper on the San Francisco-Oakland Bay Bridge, by Daniel E. Moran and Carlton S. Proctor, referred

particularly to the deep pier foundations constructed by dredging through open caissons (*ENR*, Aug. 23, 1934, p. 227 and April 5, 1934, p. 431).

Bridge construction in Denmark, whose land area is cut by numerous sounds and deep fiords, is rendered difficult by the general occurrence of soft bottom. In ordinary bridge work pile foundations are general, and since lateral as well as vertical forces require consideration batter-piles are largely used, often to the virtual exclusion of vertical piles. Recent very large bridge projects, however, required other foundation methods, according to an address by A. E. Bretting, chief engineer of Christiani & Nielson, contractors of Copenhagen.

Thus, the recently completed Little Belt bridge (*ENR*, June 13, 1935, p. 841) was founded on precast caissons sunk in water 100 ft. deep with aid of cylindrical steel piles set around their periphery to form a support during sinking and a means of retaining the surrounding clay while the interior soil was being excavated. The Storstrom bridge, a 2-mi. crossing now in course of completion, has precast concrete piers floated by a pair of scows to their place on previously built footings. The latter were constructed by excavating the clay and concreting within a ring-shaped cellular floating cofferdam assisted by a ring of sheetpiling around its base. Three or four other large bridges now projected offer equally difficult foundation problems, among them the Great Belt bridge, which will have a lift span and a 1,300-ft. cantilever span on piers to be built in 150-ft. water depth. Extensive soil studies were made to determine the bearing power of the clay before the foundations were designed.

The harbor structures at Bremen, described by Prof. Arnold Agatz, Technische Hochschule, Berlin, Germany, included mostly quay walls on piles. In these walls the design objective was consideration of the pile supports and the supported concrete wall and platform as an integral structure to resist retained earth and other lateral loads. The building foundation at Lugano, described by Giovanni Rodio, consulting engineer, Milan, Italy, involved a successful use of chemical consolidation of waterbearing soils. Attempts to excavate the full area within a sheetpile wall caused almost from the start dangerous cracking of the adjacent buildings. Called in by the general contractors to correct the trouble, Mr. Rodio resorted to excavation of the area in successive sections, chemical consolidation of the soil in and about the excavation, and the use of concrete piles cast in pipes bored to place.

Discussion of this group of papers was limited except in case of the last, which brought out a brief review, particularly of European practice, by Dr. Terzaghi. Its characteristics as compared with common practice in America are, he said, injection under much higher pressures and the use of chemicals instead of cement grout—the latter being handicapped by size of grains that clog and do not penetrate the finer fissures. With chemicals there are wide possibilities of soil penetration, as no pore-filling flocculation or formation of gels occurs until the reacting chemical solutions are in place in the soils.

Commenting on foundations in plastic soils, Lazarus White, of Spencer, White & Prentis, New York, pointed out that a foundation pit necessarily disturbs the earth regimen generally by introducing new pressures, interrupting moisture movement, and other effects. The logical method of construction, he said, is one that effects the least disturbance, and as an example he referred to the method commonly used in the clay soils of Chicago. By sinking sheeted wells, quickly filled, for interior foundations, building the walls a piece at a time in sheeted shafts, and excavating the remaining soil between wells and walls in quickly floored sections, the Chicago practice causes a minimum of soil disturbance around the pit.

A caisson innovation used in very soft soil at the site of a new lock at Ostend was mentioned by Prof. P. E. Raes, of Ghent University, Ghent, Belgium. Interior walls in the working chamber are the means of carrying the vertical load of the caisson (as in a number of earlier caissons), and the outer cutting-edges serve merely as retainers of the outside soil. Further, the surface soil was so poor that before building the caisson a bed of very lean concrete was laid down and the working chamber erected on it, after which caisson work was begun by cutting through the concrete bed.

Soil studies and tests

Soil sampling and testing as used on the Muskingum flood-control project were presented in pictorial and descriptive outline by T. T. Knappen, of the U. S. Engineer Office at Zanesville, Ohio (see *ENR*, March 26, April 9 and 23, and May 7, 1936). In a separate address, the construction methods of the larger dams of the Muskingum project were described. Prof. Glennon Gilboy, of Massachusetts Institute of Technology, Cambridge, reported in a later discussion that the time-curves of settlement of these dams due to consolidation of the subsoil under the loading of the dam were in close agreement with the curves calculated in advance from the laboratory measurements of consolidation and the known stress distribution.

Numerous detailed reports of soil sampling and testing were also given in the preprinted papers submitted for the conference. These were not presented at the sessions, however.

In the opening discussion of the subject of soil studies, D. W. Taylor, of Massachusetts Institute of Technology, stated that many difficulties in the relation between consolidation, compressibility and permeability remain to be cleared up. The variation in soil [illegible] raises question concerning the applicability of permeability calculations. Compressibility, one of the most important data of soil testing, has been best worked out for granular materials.

The shearing strength of clay, Mr. Taylor remarked, is one of the most difficult test subjects, because of the many variables involved. The direct shear test, the cylinder test and the squeezing test all are open to certain objections, as is also true of the torsion shear tests that have been tried. The recent discovery by Dr. Terzaghi that the no-load shearing strength and true angle of internal friction of clays is lower than heretofore believed is a significant development.

As to sampling, no sure way of taking undisturbed samples had yet been devised, Mr. Taylor stated. Disturbed soil probably behaves differently from undisturbed soil in most cases. Mechanical properties may not be the only determinants of soil behavior, however, and chemical and electrical properties are beginning to receive study.

Prof. H. F. Winterkorn, University of Missouri, Columbia, emphasized the influence of soil origin on properties. The parent material calls for study, especially in the case of clays. Further mention of the effect of mineralogical composition was made by A. B. Ekblad, of Springfield, Ill.

D. M. Burmister, Columbia University, New York, described a new form of squeeze test which he has developed as a measure of clay consistency. A small cylinder of the clay is compressed endwise between two glass plates under a definite load, and the ratio of final to initial diameter is taken as index. In certain cases this index has been found to be linear with moisture content, and to permit predicting the plastic and liquid limits.

Practical grading of granular soils differs from that established by conventional rules, according to Prof. W. P. Kimball, Dartmouth University, Hanover, N. H. While with Moran & Proctor he prepared a series of uniform sand and silt samples, and had them graded by a large number of practical soil workers. One finding was that the No. 8 size was the largest that they graded as sand, and that No. 200 represented the dividing line between sand and silt. He suggested that the grading terminology of practical engineers should be accepted as the recognized scientific grading.

Prof. G. Tschebotareff, Egyptian University, Cairo, reported that the swelling or non-swelling of clay has been found to be related to settlement, the swelling clays involving greater risk of serious settlement.

Temperature affects the measured value of soil properties, it was reported by C. A. Hogentogler, U. S. Bureau of Public Roads, Washington, D. C. The

penetration value may be twice as high at 40 deg. F. as at 100, and the permeability, plastic limit, etc., may also vary greatly. He attributes this effect to the change in thickness of the adsorbed water layer around the particles or molecules. Further Mr. Hogentogler expressed the view that soil is not a fixed and unchanged material but is "a living, breathing mass."

Lazarus White, of Spencer, White & Prentis, New York, sounded a caution against careless use of the value of internal friction in soil calculations, on the ground that this value may vary from zero to infinity and any formula or relation can be verified by selecting the friction angle suitably.

L. F. Cooling, of the British Building Research Station, England, urged that the shear-strength formula for clay, which makes this strength equal to a cohesion constant plus load times friction angle, is an assumption. The cohesion constant being high in clays, the validity of this assumption is not easy to test. In the direct-shear test the shear stress may give rise to a transverse compression component, whose effect is not known. He is now engaged in comparing the results of cylinder compression tests with those of direct shear.

Settlement phenomena

In opening discussion of settlement phenomena, Dr. Terzaghi set forth first the important effect of size of loaded area. The stress contour or "bulb of pressure" in the soil under the loaded area, for any given ratio of stress to load on unit area, has a constant ratio of depth to width, and the stresses therefore penetrate to greater depth under a large than under a small loaded area. Because of the different strata subjected to the stress, the settlement of the larger area will usually be different from that of the smaller area.

In plastic soils, to which virtually all settlement discussions apply, the effect of a load is two-fold; immediate deformation of elastic-solid type, in which the prism of soil under the load is compressed without volume change and bulges laterally into the adjacent bodies of soil; and a gradual depression due to volume change as the water is squeezed out of the soil and the latter slowly attains the density corresponding to the load. The change in Poisson ratio due to the volume change affects the amount of the settlement of the first type by at most 40 per cent; progressive or gradual settlement is usually much larger, and is due mainly to consolidation or the slow squeezing of water out of the soil as it adjusts its density to the load. Certain added effects are sometimes observed, resulting from influence of vibration, from mechanical readjustment of the solid particles as the share of the load originally borne by the pore water (hydrodynamic stress) is transferred to them, and from slow viscous flow of the solid particles. The latter is revealed in one observed case by the fact that settlement still continues after 40 years of loading, though hydrodynamic equalization was practically complete after 15 years and settlement should therefore have ceased.

Proof of the effect of consolidation on settlement is given by long-time observations of settlements in Holland during a period of more than a century. Under constant load the rate of settlement diminished with time, tending to a final level, but each addition of load initiated a new consolidation cycle, the whole effect tending toward an ultimate stable balance. In other tests, also in Holland, water-pressure gages sunk down to the clay soil under a dam showed at first a hydrostatic head equal to the load imposed by the dam, and then a progressive drop of this head to final equilibrium with the groundwater level as the hydrodynamic stress in the clay decreased to zero as a result of consolidation of the clay and transfer of the load from the water to the solid particles.

Soil stresses and pile foundations

Active general discussion of stress distribution in soil and the bearing power of piles followed the presentation of an extensive description of seawall failures and settlements along the German coast by Prof. A. Agatz, Technische Hochschule, Berlin, and a cyclopedic review of soil stresses under footings by Prof. E. Kögler, Bergakademie, Freiberg, Germany.

J. Stuart Crandall, Cambridge, Mass., discussing pile formulas and their place, spoke of the two main types of formula applicable to granular soils, namely

$$R = \frac{e\,W h}{s + k}\,Y,$$

and

$$R = \frac{e\,W(h - h_o)}{s}\,Y,$$

in which e is hammer efficiency, W is weight and h height of fall of hammer, s is pile penetration, k is a constant related to rebound, h_o is lost fall, and Y is a coefficient depending on type of pile and ratio of pile weight to hammer weight. The former, he said, is best for steam hammers, the latter for drop hammers. Neither is adapted for use in cohesive soils.

Pile tests are best made under static loading, but where a lever rig is used the possibility of high values due to arching should be considered. Fuller data on point resistance and skin resistance are desirable, as by driving a test pile inside a tube to separate the two values. In fixing the relation between the action of one pile and of a group, the effect of soil strength below the piles, of which little is known, is a main factor. A rule adopted for the new Boston building code draft is worth consideration: 60-deg. spread of the load from the pile top, and uniform distribution of this loading at any level.

A report of experience in driving nearly 10,000 steel H-piles in Nebraska was given by J. G. Mason, Lincoln, bridge engineer of the state department of roads and irrigation. Of these about one-third rest in clay, one-third in sand, 13 per cent in gravel, and 21 per cent go to rock. Since 1931 more than 35 per cent of the piles driven on state work have been of steel H type. The load capacity of the piles computed from driving penetration varies directly as the depth in case of sand, while in clay the load-depth curve is nearly parabolic, the increase of capacity becoming smaller with depth. R. Pietkowski, Warsaw, Poland, stated that in determining the capacity of a group of piles the overlap of pressure bulbs of the individual piles is important only if the spacing is below a certain minimum.

E. F. Littleton, Tufts College, Medford, Mass., discussed the stress distribution from an interior load in a semi-infinite solid, and D. M. Burmister, Columbia University, New York, described a graphical method for superposing the pressure-distribution contours of individual piles to get the group capacity.

B. K. Hough, Jr., of the U. S. Engineer Office at Eastport, Me., discussed the effect of rigid boundaries (such as the surface of bed rock) on the stress distribution in a layer of plastic soil. Gelatine model tests have been made in connection with the Passamaquoddy dams to determine the shear distribution in such cases as a basis for estimating the hazard of flow failure of the clay foundation.

Lazarus White expressed the view that no formula is of any value in determining soil resistance because of the many variables and unknowns. D. P. Krynine, Yale University, New Haven, Conn., also spoke of the unknowns.

Lateral pile resistance was briefly discussed by Prof. P. E. Raes, Ghent, Belgium, who questioned the position of the center of rotation. A. E. Cummings, Raymond Concrete Pile Co., Chicago, reported some small-scale tests to determine this center, concluding that pivoting is not possible. K. Haugeto, M. W. Kellogg Co., New York, suggested that earthquake resistance of piles is often important, but is unknown.

Carlton S. Proctor, of Moran & Proctor, New York, urged consideration of the stresses set up in the pile by driving, in view of many cases of pile destruction in driving. Formulas to compute such stresses are needed. Prof G. Tschebotareff, Cairo, Egypt, told of differences in settlement of three school buildings in the Nile Delta because of difference in length of the piles, in clay soil overlying sand; settlement was minimized only when the piles were long enough to reach the sand.

A continuation of this report, together with abstracts of some of the papers, will be published in subsequent issues.

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ENGINEERING NEWS-RECORD is a consolidation of Engineering News and Engineering Record, effected in 1917. The Contractor was consolidated with Engineering News Record in 1918. Engineering News was founded in 1874 by George H. Frost, as The Engineer and Surveyor, which title subsequently became The Engineer, Architect and Surveyor, then Engineering News and American Railway Journal and finally Engineering News. Engineering Record was established in 1877 by Henry C. Meyer, as The Plumber and Sanitary Engineer. The name was subsequently changed to The Sanitary Engineer, Engineering and Building Record, and, finally, to Engineering Record.

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Points and Benchmarks

A CALL FOR HELP was sounded by the Soils Conference last week. Addressing itself to all engineers, it appeals to them for active aid in collecting data on ground settlement under the load of buildings and engineering structures. At present the tangible information on amount and rate of settlement is woefully scarce, too scarce to allow that wide correlation between soil characteristics and load effects that we must have for surest results in construction. As one observer put it: Heretofore no one took precise observations on the settlement of a building until the building cracked—and then it was usually too late for measurement, as the prior settlement history was lost. In the light of this remark it appears clear that every structure of some importance should be fitted with indestructible survey points, that a dependably fixed benchmark should be established nearby, and that accurate levels should be taken from the time building begins to at least the time of its completion. Provision of this kind can soon bring together a stock of data which, when coupled with soil profiles and physical tests, will establish an adequate basis of knowledge of soil behavior and the security of foundation and construction practice.

Not All Routine

MAINTENANCE PROBLEMS nearly always are rated as more routinized and less exacting than those of construction, and as calling for less initiative and forceful action. But fuller knowledge of the maintenance man's problems shows that conclusion to be false. Though usually he has more work that is of a routine nature than does the man on construction, yet from time to time—and on some operations quite frequently—he has to meet problems demanding all that is ever demanded of the construction engineer. The truth of this statement is evident in what Clyde E. Learned of the Bureau of Public Roads says in his account of snow-removal work on highways at high altitudes in the Rocky Mountains. "A blinding snowstorm during a night run is no place for an inexperienced or timid plow operator." Anyone who has ever operated a railway or a highway plow under such conditions knows the truth of that statement. The work calls for the pick of the maintenance men, either in highway or railway work. They must be enthusiastic for their job and willing to take risks. Above all, the work calls for careful advance planning and able direction. Equipment must be in first-class condition at all times, and when the call for action comes the picked crews must be organized and ready as an army going into action. Even more severe demands on initiative are often made by flood conditions. Seen in full perspective, the maintenance engineer's job is anything but all routine.

Earthquakes and Dams

IN RECENT years earthquake resistance has become a familiar term to the structural engineer, particularly in regions of frequent seismic activity. With proper design a small percentage of the first cost of framed structures will provide rigidity sufficient to prevent serious damage from moderate shocks and to minify damage from more violent seismic disturbances. Unfortunately, it takes more than a "small percentage" of first cost to get corresponding protection in dams, but at least there are ways of increasing the ability of dams to withstand seismic shock. The design of Coyote Dam, located on an active earthquake fault above the city of San Jose, Calif., was developed with the primary objective of building a structure that would function during and after a severe earthquake. The builders frankly concede the probability of such a shock, and recognize that the dam is located in a place where it will feel the maximum effect—though in this valley practically all dam sites are on fault lines. Among other novel features of the Coyote Dam is the scheme of locating the bulk of the structure upstream from the constriction in the canyon which constitutes the dam abutments. Recognition of the risk from earthquakes and means for neutralizing their effects have made rapid progress, so rapid that the residents of a populous district such as the Santa Clara Valley are willing to store large quantities of water above their homes behind an earthquake-proof dam.

Wishful Thinking

GLENN FRANK, president of the University of Wisconsin, in addressing last week's convention of the Society for the Promotion of Engineering Education, urged a closer alliance between the physical scientist and the social scientist as a solution of economic maladjustment. Admiration for Dr. Frank's courage in attacking one of the most troublesome problems confronting modern civilization must be accompanied by skepticism regarding his belief that such cooperation is workable. How, for example, would the social scientist have met the "threat" of the photo-electric cell to change industrial processes if he had been appraised of its potentialities ten years ago? How, indeed, would the physical scientist, working on the perfection of the cell, have explained the importance of his development to the social scientist when he did not know its possibilities himself? Often the physical scientist has no idea what he is searching for, much less what will be its impact on society. Dr. Frank recognizes this by stating that pure science must be allowed to continue unhampered but that "research" should be planned to take account of its results. The research that is referred to usually is commercial, and it always is secret. Its purpose is to give one company or industry an advantage over competitors, and permitting the social scientist access to the early results would defeat the purpose of the research. But most important as a deterrent to the desirable cooperation is human inadequacy. The social scientist can no more chart a course for the next twenty years than an automobile driver can outline his moves through crowded traffic in advance. Dr. Frank's conclusion that "the race between scientific progress and social stability" can be made a draw by collusion between the racers must be set down as wishful thinking. Neither racer is a good enough judge of pace.

A Milestone

THROUGH the remarkable meeting of soil students and engineers that was held last week at Harvard University as the First International Conference on Soil Mechanics and Foundation Engineering, a highly important new engineering science formally took its place in the domain of the civil engineer. It was not new born, for it has been growing for a dozen years past. The conference, however, represented its confirmation as an essential and competent component of engineering science. Coupled with this new science, moreover, is a new engineering art, that of controlling earth actions and constructing in earth. Younger even than the science, it also has a record of accomplishment and high promise of future performance.

The conference was a milestone in engineering history. Dealing with the oldest material known to man, a material that through uncounted centuries had been handled by pure empiricism in the face of an increasing number of baffling problems, it has begun the attack on the involved subject of earth properties and earth behavior in an ideally scientific manner—by isolation of individual properties and measurement of their value by test under different conditions. The extraordinary fruitfulness of this attack has already been demonstrated by abundant evidence—as in predetermining safe methods of ground support, in shaping the design of foundations whose stability must be assured against settlement, and in showing how earth dams can be safeguarded against both percolation and subsidence. On the strength of such performance, achieved in less than two decades since its birth, the new science gives assured promise of large contribution to the future of civil engineering.

Already construction to the amount of several hundreds of millions of dollars is being controlled by knowledge derived from the new science. It is not fantastic to look forward to the time when all of our work in earth and all of our dependence on the stability of the earth's surface will be guided by this same knowledge. The size of the field thus marked out almost transcends imagination, since the largest part of the world's construction expenditure is for work in earth.

Such a record and such promise suffice to place the father of the new science, Dr. Karl Terzaghi, among the great creative figures of the annals of civil engineering. From his early experiments, conducted with most primitive facilities in an obscure laboratory in Constantinople, he developed a perception of the fundamentals of soil behavior that, despite its academic aspect, proved to open up a door of possibilities never before imagined, and at a stroke overthrew the artificial structure of the "classical" theories of earth action and earth pressure. As soon as the new concepts and observations were applied to practical problems, the wide gulf that previously existed between earth theory and earth practice narrowed, and with each new application it closed further. Field knowledge and laboratory analysis were enabled to join hands in effective attack on the engineer's difficulties with earth.

Never has there been so powerful and rapid a growth in the history of civil engineering. The new understanding of granular soils, which correlated their behavior with density, stability and readjustment, and the new view of elastic or cohesive soils, which involves the study of moisture content, consolidation, distortional deformation and shear failure, has made possible an extensive reorientation of the art of building foundations, of the knowledge of slopes, slides, and a host of other problems. The rapid growth has necessarily meant constant change; conclusions and theories often became obsolete as soon as additional experiment revealed new factors or new behavior. This process of change is bound to continue, and for years to come we will not be able to claim even approximate completion or perfection of the art. But it is worth remarking that so basic an element of the new science as the relation of water to fine-grained soil in respect to consolidation and stress action has remained fundamental and has undergone little change since the first days of the new science.

Such exuberant growth could not fail to bring with it some apparent confusion—through clash of fact and opinion as well as through the unavoidable imperfection of data. This was to be expected, and those who look for assured and dogmatic knowledge in so new a field, or who would like to place its school treatment on the same basis as the teaching of an old-established exact science, are likely to find themselves in error. Just now it is especially important to keep this in mind. Dogmatic engineering conclusions do not accord with change, growth and constant lack of perfection; and any tendency of schools to teach the subject as a finished and established science must therefore be avoided with care. All the theories of the science should for the present be looked upon as tentative only, and should not be regarded as infallible or as being capable of application without the exercise of far-seeing judgment on the part of the engineer. Accordingly the schools should aim to teach a method rather than a system—the habit of investigation and thought, in place of laws and rules.

To speculate more fully at this time on the future of soil mechanics and the engineering of earth is neither necessary nor useful. But we cannot refrain from speaking of the extraordinary character of the Cambridge meeting. As an international gathering it was successful beyond precedent, operating with a smoothness and efficiency never before seen where delegates from 20 countries came together. This was in part due to the enthusiasm of all present, and to the fortunate fact that the whole proceedings could be conducted in one language. But in even greater degree it resulted from the prodigious larbor and amazing skill of arrangement displayed by the working committee that organized the conference. Prof. Arthur Casagrande and his fellow-workers covered themselves with glory—and not only by their work in organizing the sessions themselves, but even more by the infinite patience and industry which they devoted to abstracting and publishing the papers of the conference in advance—in two massive printed volumes that will remain cornerstones of the new art of engineering in earth.

Beyond any question so important and promising an activity must continue. The intense interest in applying soil knowledge to practical work and in further exploring its scientific basis cannot do other than bring about further national and international exchange of thought, organized if possible, spontaneous if need be. The resolution of the conference to continue its organizing committee was therefore most fitting, and is entitled to welcome and appreciation by the entire profession. The details of how the continuing cooperation is to be managed are at the moment unimportant; the important thing is that the will has been expressed to maintain touch throughout the world in fostering a growth that is certain to influence profoundly the whole range of the civil engineer's future labors.

CURRENT NEWS

Slum Clearance Law For Buffalo

Buffalo charter amended to give city authorities power to remove unsafe or insanitary structures—provision for court review

THE GOVENOR has signed an act passed by the New York State legislature amending the charter of the city of Buffalo to provide a mechanism for slum clearance.

The amendment requires that notice shall be served upon the owner of an unsafe building by the Commissioner of Public Works, and of an insanitary building by the Board of Health, requiring him either to remove the building or to render it safe or sanitary. If the owner of the property fails, within ten days, to give notice of his intention to perform the required work, a survey of the property shall be made by a committee of three members. In the case of an unsafe building, one member of the committee shall be an inspector from the Department of Buildings, another shall be an architect appointed by the Buffalo Chapter of the American Institute of Architects, and a third shall be a builder, engineer, or architect appointed by the owner. In the case of an insanitary building, one member shall be a health commissioner appointed by the Board of Health, another shall be a physician appointed by the Erie County Medical Society, and a third shall be a physician appointed by the owner. Payment of the two members of the committee not city employees shall constitute a lien upon the property in question.

The report of the committee making the survey shall be submitted to the county court for decision. Cases arising under this act shall have precedence over all other cases before the court. If the court finds that the building is in fact unsafe or insanitary, the Commissioner of Public Works or the Board of Health shall be directed to repair or remove the building.

The cost of such repair or removal is charged to the owner of the property and constitutes a first lien against the property. No deficiency judgment, however, will be brought against the owner of the property.

The act also includes provisions empowering the Commissioner of Public Works to take action for the removal of bodies from fallen buildings and for the vacating of unsafe buildings.

New Building Started For Rockefeller Center

Work has started on the excavation for the eleventh unit in Rockefeller Center, a 34-story office building. The 427-ft. building, which is being built by the Todd-Brown Co., will be ready for occupancy in May 1937. The building will have a frontage of 150 ft. on 48th St., 90 ft. on 49th St., and 182 ft. on Rockefeller Plaza, the street through Rockefeller Center.

Character Building is Keynote At S.P.E.E. Convention

Engineering teachers consider ways of imparting morals and manners—Group conferences cover technical teaching

TURNING from the strict field of technical pedagogy to those phases of engineering instruction that concern character building, graduate study and research, the 44th annual convention of the Society for the Promotion of Engineering Education, held last week on the campus of the University of Wisconsin at Madison, sought to direct thinking along lines which recent developments have demonstrated need attention. The program of the general sessions was concerned with the "spiritual adjustment of the engineering student" while some twenty-five group meetings provided the opportunity to discuss specialist subjects and detailed teaching problems. The attendance was slightly under 1,200.

The new president is H. P. Hammond of Brooklyn Polytechnic Institute. Miss Sada H. Harbarger (Ohio State University) and Ivan S. Crawford (University of Idaho) were elected vice-presidents. The society's award of merit, the Lamme medal, was presented to Herman B. Schneider, president emeritus of the University of Cincinnati.

In the civil engineering division Linton E. Grinter (Texas A&M College) and K. C. Reynolds (Massachusetts Institute of Technology) were elected chairman and secretary to succeed Fred L. Plummer (Case School of Applied Science) and H. C. Bird (Duke University). New directors are Hale Sutherland (Lehigh University) and F. T. Mavis (University of Iowa).

The convention was addressed by Glenn Frank, president of the University of Wisconsin, and by Phillip F. LaFollette, governor of the state. President Frank urged a closer cooperation between the physical scientist and the social scientist to the end that the latter may prepare society to cope with scientific discoveries at the time they come into use. He held that economic dislocations could thus be minimized and the impact of scientific discoveries "modulated and humanized." Unless this is done the "revolt against science" may reach dangerous proportions, according to President Frank. The University of Wisconsin is instituting an attempt at such coordination through a project known as the "social inquiry." Governor LaFollette's address also dealt with the engineer's contribution to economic progress. In it he paid high tribute to Dean F. E. Turneaure of the University of Wisconsin as an engineering educator with a proper appreciation of the engineer's responsibility to current affairs and economic progress.

Research

A slightly different aspect of research coordination was discussed in several group conferences where the possibility of keeping all laboratories informed of work under way elsewhere was debated. The fifty land grant colleges publish a quarterly list of such projects in their laboratories but the opinion seemed to be that this would not be practicable with a larger group, that it was not the responsibility of the S.P.E.E. to supervise this coordination and that the usefulness of such information has not been definitely established.

Graduate study

Considerable interest was manifest in the report of a committee on graduate work, H. P. Hammond, Brooklyn Polytechnic Institute, chairman. Graduate study has advanced to a position of great significance in recent years, and its handling is closely associated with the question of the proper length of the undergraduate curriculum. The committee feels that graduate work should be quite distinct from undergradu-

THE NEW HIGHWAY BRIDGE across the Waal in Holland, dedicated on June 16, is the longest steel arch in Europe, with a span of 790 ft. The Bayonne Bridge at New York has a span of 1,675 ft. and the Sydney Harbor Bridge, a heavier structure, has a span of 1,650 ft.

ate study and not a continuation of it. Also that it is better to confine present efforts to developing a program leading to the master's degree rather than taking up more advanced plans for doctorate studies. The committee reported that present graduate studies are almost exclusively technical and that little consideration is being given to advanced work in economics and other liberal and humanistic subjects. Graduate teachers are badly needed.

Civil engineering conferences

Some 200 teachers attended the civil engineering groups of which about 70 were in the structural section and 90 in the hydraulics and sanitary section. Hale Sutherland, Lehigh University, in outlining trends in structural engineering, concluded with several significant suggestions. Because the mass of new material required to be covered is greater than ever before and at the same time more hours are required for English, economics, history and government, competent structural engineers cannot be turned out in four years. Five-year courses for all students being out of the question, Professor Sutherland suggests a year of graduate study *after* a year of practical work in the field for those aspiring to structural competency. Vacations should *all* be spent in engineering work. In undergraduate work a two term course in mechanics should be required giving the student training in such subjects as general bending, impact and energy loads, curved beams, flat plates, torsional stresses and indeterminate analysis. Undergraduates should also be introduced to dynamic and earthquake designs. Advanced mathematics is very necessary for the graduate year, in Professor Sutherland's opinion.

In addition to a large number of papers on teaching practices there were also several of more general interest presented. Among these was one on industrial building by Waldo G. Bowman, associate editor, *Engineering News-Record*, which pointed out the obsolete character of college textbooks in their treatment of the so-called mill building. Technical developments in sanitary engineering, by R. G. Tyler (University of Washington); a rational theory of clarification by sedimentation, by T. R. Camp (Massachusetts Institute of Technology); and chemical treatment of sewage, by Langdon Pearse of the Sanitary District of Chicago, were titles of other papers in this general interest group.

More Contracts Awarded On Buffalo Sewer Job

Contracts totaling $2,625,906 on Buffalo's $15,000,000 sewer and sewage disposal projects were awarded on June 23. The awards, covering construction of divisions K, L & M, of the intercepting sewer, were made to H. W. Horst, of Philadelphia; P. W. Graham, of Toledo; and Connelly Bros., of Cincinnati; respectively.

On June 26 contract for construction of Division J, a section of the Bird Ave. storm sewer, was awarded to Frank L. Cohen of Buffalo, on a bid of $659,054. The estimate on this section of the work was $1,068,776.

By July 1, about $6,000,000 worth of the work is expected to be actually under construction.

Commission Appointed For Goethals Memorial

President Roosevelt has appointed a commission to prepare plans for the erection of a memorial in the Panama Canal zone to Major General George W. Goethals, the builder of the Panama Canal. The members of the commission are: Gen. John J. Pershing; Congressman Morris Sheppard, of Texas; Col. John Fallan O'Laughlin, chairman of the Goethals Memorial Committee; Col. Julian L. Schley, governer of the Panama Canal Zone; Congressman Swager Sherley, of Kentucky, member of the House Appropriations Committee during the construction of the Panama Canal; Robert E. Wood, of Chicago, president of Sears Roebuck Co., chief quartermaster and director of the Panama Railroad Co. during construction of the Panama Canal.

It will be the duty of the commission to recommend to the president the character of the design ot the memorial and the site where it will be erected, and to submit an estimate of cost.

Transfer of Authority Voids Bids on Dam in Texas

Bids for the construction of dam No. 2 (Arnold dam) on the Colorado River of Texas project were rejected when construction of the project was turned over by the Bureau of Reclamation to the Lower Colorado River Authority, an organ of the state of Texas. Although the bids were rejected by the bureau, they were turned over to the Colorado River Authority, which may award the contract without readvertisement, if it so desires.

The Colorado River of Texas project consists of a series of dams between Bluffton, Texas, and Austin, Texas. No. 1 dam originally was begun by a private utility company but was left incomplete. Completion of this dam has already been started by the Bureau of Reclamation, and the contracts for the work have been turned over to the authority. The project includes flood control, generation of power, and aids to navigation and irrigation.

The Lower Colorado River Authority was set up by the Texas legislature. It received a grant of $4,500,000 and a loan of $10,500,000 from emergency funds, last year, through the Public Works Administration, for construction on the project. In addition, the Bureau of Reclamation was allotted $5,000,000 to be spent on the project as the government's contribution in return for flood control benefits. The original contract between the government and the authority designated the Bureau of Reclamation as construction agency for the entire project. The new agreement will permit the authority to become its own construction agency except that the Bureau of Reclamation will construct a flood control dam as its part of the project.

The Colorado River Authority, on June 22, awarded the contract for construction of the Roy Inks Dam (one of the dams in the project) to the Morrison-Knudsen Co. of Boise, Idaho, on a bid of $783,773. The authority will furnish all materials. Contract to furnish sand, gravel, and crushed rock for the Roy Inks and the Hamilton Dam was awarded to the Austin Bridge Co. on a bid of $448,120.

Deficient Rainfall in West Brings Threat of New Drought

Threat of a new drought, possibly as severe as the great drought of 1934, is found in the continued deficiency of rainfall in states of the Middle West and in some of the South Central States.

Weather Bureau officials are non-committal, but the latest weekly weather and crop bulletin reveals that only a short prolongation of present conditions will result in a drought creating as much damage and distress as the 1934 disaster. The bureau reports that there is now a wide-spread need for rain in most of the farming sections of the country. Showers in recent weeks have been beneficial in local areas but the bulk of the crop lands between the Rocky and Appalachian mountains have been missed.

For three months North Dakota has had only about one-third of normal rainfall, eastern Montana and northern Minnesota less than one-half, and other northwestern sections only slightly more. Interior states, such as Arkansas and much of Missouri, have had less than half the normal since beginning of April. Other states have had even greater shortages. Since May 1 Tennessee has had only 25 per cent of normal precipitation, Kentucky about the same, and other Ohio valley states less than half a normal supply for this season of the year.

In the Rocky Mountain and Great Basin states irrigated farming is doing well but dry farming operations are only turning up dust. The stock feed and water situation is critical in the Northwest, especially eastern Montana, the Dakotas and Wyoming. Thousands of head of cattle are on the move because of lack of feed and water. The Northern Pacific Ry. has been authorized by the Interstate Commerce Commission to reduce rates on livestock from drought striken areas in Montana and North Dakota to all available feeding points on its lines.

Indirect Employment from PWA

Administrator Harold L. Ickes reports that with more than 95 per cent of the projects in the current PWA program under way, nearly 60 per cent of the public works money spent thus far has gone for materials. A total of $1,331,500,000 was spent for materials up to June 1.

As of June 1, $678,832,000 had been spent for iron and steel products. Industries furnishing cement, brick, stone, lath, sand, gravel, and similar materials for public works jobs, received orders totaling $383,340,000. Lumber and forest product orders totaled $71,250,000. The chemical industry has received $10,242,000. The textile industry has received orders for $1,477,000.

The report estimates that at least 70 per cent of the expenditures for materials went into wages. The expenditure for materials, up to June 1, was nearly twice the amount paid in wages to men employed directly on construction sites. This amount of wages was $735,456,000.

Up to May 1, more than 68,000,000 man-months of labor had been furnished. Projects completed were estimated to cost $1,164,770,000 while projects under construction at present are estimated to cost $2,331,885,000.

Fatal Collapse Starts Study of N. Y. Building Law Enforcement

As an outgrowth of the collapse on June 19 of an apartment house in the borough of the Bronx, New York City, in which seventeen men lost their lives, architects and engineers in that borough have begun a study of means for obtaining better enforcement of state and city building laws.

On June 24 representatives of the Bronx Society of Architects and of the Bronx County Chapter of the New York State Society of Professional Engineers determined upon the appointment of a joint committee, to be known as the joint committee of professional engineers and architects, to study and make recommendations for the strenghtening and enforcement of state and municipal laws designed to safeguard life and property in the field of building construction. The committee is to be composed of eight members, four to be appointed by George J. Cavalieri, president of the Bronx Society of Architects, and four by Raymond J. Van Wagner, president of the Bronx County Chapter of the Professional Engineers.

The reason for the collapse of the apartment house under construction on Mosholu Parkway (*E.N.R.* June 25, p. 930) is still a mystery. The district attorney is continuing his investigation and has named experts to make an examination of the structure in an effort to determine why the central section collapsed.

Soil Conservation Conference

A conference on the engineering aspects of upstream river-control in its relation to flood and erosion prevention has been called by Secretary of Agriculture Wallace. The conference will be held in Washington, in September, and will be international in character. A special committee to represent the government has been appointed by the President: H. H. Bennett, chief of the Soil Conservation Service; F. A. Silcox, chief of the Forest Service; and Morris L. Cooke, administrator of the Rural Electrification Administration.

The conference was called at the suggestion of the President. President Roosevelt in a letter to the Secretary of Agriculture stated that "upstream engineering will have a major part in the effort to save the land and control floods, and for that reason it offers a very broad field of opportunity for the engineering profession. There are indications that a substantial body of technical information on the control of little waters is now available in the scattered records of American experience—federal, state and professional. . . . The objects of upstream engineering are through forestry and land management to keep water out of our streams, to control its action once in the stream and generally to retard the journey of the rain drop to the sea."

The conference will be held at a date near to that of the third World Power Conference.

Awards for Beautiful Bridges

The North Grand Island bridge at Niagara Falls, N. Y.; the Lorain Road bridge at Cleveland, Ohio; and the Mortimer E. Cooley bridge over the Manistee River near Wellston, Mich., have been declared the most beautiful bridges built during the past year by a jury named by the American Institute of Steel Construction. The bridges will receive the institute's annual award.

The award was made by a jury composed of: Robert D. Kohn and Arthur Loomis Harmon, New York architects; William J. Krefeld, professor of engineering at Columbia University; Howard C. Baird, New York consulting engineer; and Kenneth Hayes Miller, artist, of New York City.

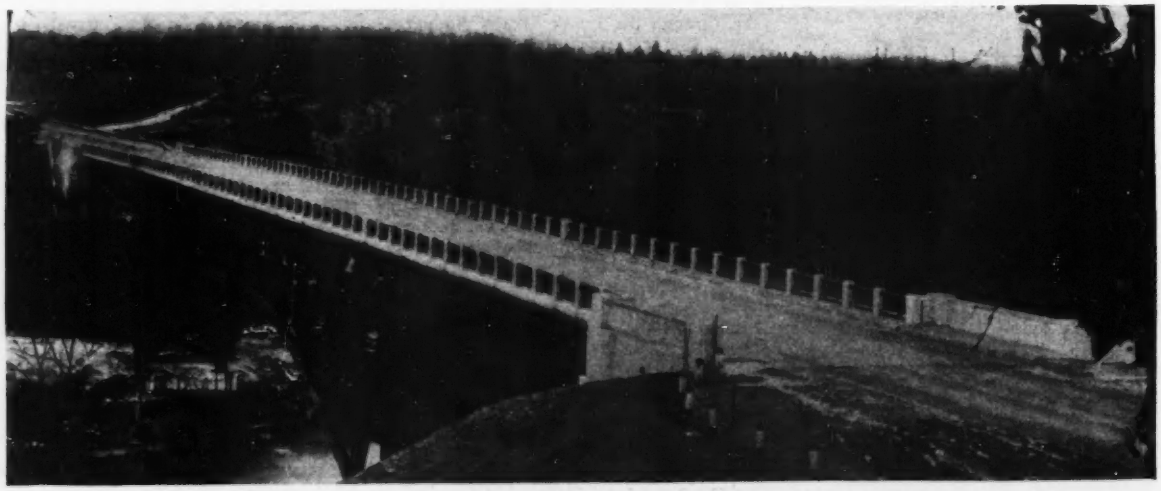
Three awards were made, for different classes of bridges. The first class included bridges costing $1,000,000 or more. The Grand Island bridge received first place in this group. This bridge was designed by Waddell & Hardesty, and George C. Diehl, Inc., consulting engineers. Honorable mention in this class was awarded to the Sagamore bridge across the Cape Cod Canal in the town of Bourne, Mass. The second group included bridges costing between $250,000 and $1,000,000. First place in this group was awarded the Lorain Road bridge, Cleveland, designed by the bureau of bridges of the Ohio department of highways. Honorable mention in this group was awarded to the Tower bridge over the Sacramento River between Sacramento and Yolo counties, Calif. The third group of bridges included those costing less than $250,000. First place in this group was awarded the Mortimer E. Cooley bridge, Wellston, Mich. It was designed by L. W. Millard, state highway bridge engineer. Honorable mention in this group went to the Tamm Ave. grade separation in St. Louis, Mo.

This is the eighth year in which the American Institute of Steel Construction has made this award.

N. Y. Sewage Works Association Meets on Long Island

Two hundred and sixty members and guests attended the spring meeting of the New York State Sewage Works Association at Lido Beach, L. I., June 11-13.

Papers read at the meeting included a report on the experiments on activated carbon at the Ithaca sewage treatment plant, by Prof. Charles L. Walker of Cornell University; a talk on "Buying Community Sanitation at Reduced Cost Through WPA Projects," by H. P. F. Howe, district director, Works Progress Administration on Long Island; a paper on the sewage disposal program for Nassau County, by Clarence MacCallum, consulting engineer, Nassau County Sanitation Commission; a paper on "Methods for Operating the Activated Sludge Plant at Rockville Center and Prevention of Bulking," by Seth Hess, assistant engineer of inspection of the PWA; a paper on the disposal of garbage in sewers, by Albert C. Rogel, of New York University. A symposium on sludge utilization was also held. Lithgow Osborne, state commissioner of conservation, spoke at the banquet.



THE MORTIMER E. COOLEY Bridge over the Manistee River near Wellston, Mich.—prize winner in its class.

Army Engineers Force Expanded Due to Added Assignments

Among the bills approved during the closing days of Congress was one providing for an increase in the commissioned strength of the Corps of Engineers, U. S. Army, in order to permit the army engineers to handle the unusually large number of assignments made to them under legislation passed this year. The act provides for one additional assistant to the Chief of Engineers with the rank of brigadier-general and 185 additional officers in grades from colonel to second lieutenant. To provide for these additions to the Corps of Engineers, the President has been authorized to call to active duty in the regular army such number of officers of the organized reserve as may be necessary and for the length of time necessary to carry out the wishes of Congress.

Congress enacted two flood control bills, one modifying the plans for the Mississippi River flood control and one for general flood control. The Corps of Egineers is charged with execution of the provisions of both bills, also the work included under the large appropriations authorized for river and harbor improvement. Altogether, Congress authorized the expenditure of nearly one billion dollars on work to be carried out under the direction of the army engineers.

Court Declines to Stop Work On St. Louis Memorial Park

A suit, entered by St. Louis taxpayers, seeking an injunction against the proposed Jefferson memorial project in that city, and contending that the Emergency Relief Act, under which PWA has allotted $6,000,000 to the project, is unconstitutional, has been decided in favor of the government by the supreme court of the District of Columbia. The court refused to accept the argument that there is any connection between the present case and the recent decision of the court of appeals of the District of Columbia which held the Act invalid and stopped work on a housing project of the Resettlement Administration at Bound Brook, N. J. The court cited the Historic Sites Act as authorizing the government to contribute to the St. Louis project although memorial projects are not referred to directly in the Emergency Relief Act.

Award for Anticipated Profits Disallowed by Appeals Court

The United States Circuit Court of Appeals at New Orleans has reversed a district court decision awarding the firm of Murphy & Prior, contractors, a judgment of $241,128 against the city of Orlando, Fla. Orlando made a contract with the contracting firm for paving amounting to about $2,500,000 in 1925, the work to be completed in the next two years. The work was two-thirds finished in 1930, when the city stopped the work by failure to complete its efforts to finance the remainder of the project. Suit was brought in federal district court in 1932, and the jury's decision was in favor of the contractor. He was allowed a balance on work and materials of $1,817; he was further allowed the sum of $202,195 as anticipated profits on uncompleted work, $14,114 for unnecessary expenses for periods of delay, and $23,001 for overhead.

The Court of Appeals reversed the award for anticipated profit. The court also disallowed damages for delays, because extensions of time were provided the contractor to complete the work when necessary. The court stated that both parties contemplated that it might be necessary to abandon the contract when they started the work, because the special fund provided could not be replaced when it was exhausted.

Votes Favor Public Ownership

Results of a study of election returns on the issue of public vs. private ownership of power facilities have been announced by the Public Works Administration. The study covered 132 communities in 32 states.

The balloting was either on local policy proposals or on bond authorizations for power purposes. Of 494,675 ballots analyzed, 59 per cent favored municipal ownership. Of the 132 communities 112, or 82 per cent favored public ownership. Of the remaining 20 communities three cast more than a majority for public ownership, but failed to obtain a necessary two-thirds majority. In one Iowa town the vote was a tie, 1,915 to 1,915.

P.W.A. also reported that work on 62 power projects located in 26 states is now held up by litigation. Allotments for these projects total $69,706,739; total estimated construction costs $108,801,039. Federal courts in the District of Columbia have 39 of these cases; other federal courts 14; while 9 cases are in various state courts. Under construction are 103 electric and 5 gas projects with a total estimated construction cost of $115,729,962. To date 65 electric and 9 gas projects have been completed at a total cost of $9,579,084.

Labor Shortage in Missouri

Contractors for the million and a quarter dollars of PWA building at the University of Missouri at Columbia, Mo., are finding it necessary to pay a premium above the basic PWA wage scale in order to obtain skilled workmen. In many cases the wage that must be paid is double the basic scale laid down by federal authorities. Under the PWA scale in this locality, carpenters receive $1 per hour, bricklayers $1.10, stonemasons $1.10, cement finishers, 75 cents, common laborers 50 cents, and others in about the same proportion. These figures must now be exceeded from 10 per cent to 100 per cent to get skilled labor. There is an abundance of common labor.

Additional projects totaling about 6½ million dollars of buildings are expected to start within a month. After all jobs now contemplated have been started, there will be approximately $10,000,000 worth of building construction going on within an area of 30 miles radius, in the central portion of Missouri. The largest town in this area has a population of less than 25,000, and the surrounding territory is not thickly populated. At present the National Reemployment Office is referring requests for skilled labor for most of the projects to unions in Kansas City and St. Louis.

Montreal Intake Approved

The board of five engineers appointed a year ago to inquire into the water supply situation of Montreal (*ENR*, Sept. 5, 1935, p. 342), have completed its report on the recent developments regarding the proposed new intake for Montreal, and its unanimous findings have been presented to the city executive committee. The board examined the bids received for the work, and the many alternative plans which have been submitted to the city. The report now presented endorses in every respect

HALF A MILLION CUBIC YARDS of concrete have been poured in the western abutment of Grand Coulee dam, rising to more than 90 ft. above bedrock.

the plans of the chief engineer of the Montreal Water Board, and recommends the immediate construction of the four-pipe intake for which bids have already been received.

The project under consideration (*ENR*, Dec. 19, 1935, p. 849), contemplates replacing the present intake in the St. Lawrence River, which is close to the shore and receives considerable ground water as well as the muddy water of the Ottawa River, with a new intake in the center of the river.

Brief News

THE CONTRACT TO BUILD and place the eight emergency gates in the four tunnels, together with operating machinery and electrical equipment, for the Fort Peck Dam, has been awarded to Bartlett-Hayward Co. The bid was $1,093,609.

CONTRACT HAS BEEN AWARDED to Reilly & Quinn, of Youngstown, to relocate about 26 miles of the Wheeling and Lake Erie R.R. main-line track in connection with the $34,000,000 water conservation project in the Muskingum Valley.

PREPARATIONS FOR THE CONSTRUCTION of the navigation locks at Guntersville dam are under way. Cofferdam for the lock was unwatered on June 15. The coffer consists of 36 cells of sheet steel piling filled with chert. The lock chamber will be 360 ft. long and 60 ft. wide. The lock will be a single lift, with a maximum lift of 45 ft. About 1,000 men are now at work at Guntersville.

THE FIRST CAISSON was placed June 8 for the new $3,500,000 bridge under construction over the Connecticut River between Middletown and Portland, Conn. (*ENR*, Apr. 30, p. 646), on the Middletown side of the river. The caisson was sunk 108 ft. in two sections in lengths of 40 and 68 ft. respectively. Caissons will be sunk for eight piers. No compressed air is used with these hollow steel caissons which are rotated to bearing. Merritt, Chapman, and Scott Corp. has the contract for the substructure.

ESTABLISHMENT AT UNIVERSITY OF MARYLAND of an institute of transportation, embodying as its first unit a $500,000 library and road building exhibit, was announced June 6, by Charles Henry Davis, of New York City. Plans for construction of the first of a proposed group of buildings on the Maryland campus will be announced in the fall. The American Road Builders Association is interested in the project, and contact is being established with the representatives of other transportation and communication interests.

CONTRACT FOR THE CONSTRUCTION of the New York land ventilation building of the new Midtown Hudson Tunnel has been awarded by the Port of New York Authority to the George Colon Contracting Corp. on a bid of $427,000. The building will have four stories and a penthouse; it will consist of a steel frame enclosed with face brick exterior walls. The contract must be completed to the point where the ventilation and electrical equipment may be installed by other contractors by Jan. 1, 1937; all work must be finished by July 1, 1937.

SOCIETY CALENDAR

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Portland, Oregon, July 15-17.

CANADIAN GOOD ROADS ASSOCIATION, annual meeting, Charlottetown, P.E.I., September 1-3.

PUBLIC WORKS CONGRESS, joint meeting, AMERICAN SOCIETY OF MUNICIPAL ENGINEERS AND INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS, Toronto, Ont., September 28-30.

CANADIAN INSTITUTE OF SEWAGE AND SANITATION, Royal York Hotel, Toronto, Oct. 1-2, 1936.

THE NORTH AND SOUTH CAROLINA SECTIONS, ASSOCIATD GENERAL CONTRACTORS OF AMERICA, and SOUTH CAROLINA SOCIETY OF ENGINEERS, joint summer meeting; Myrtle Beach, S. C., July 10-11.

Personals

NATHANIEL A. CARLE has been appointed city engineer of Seattle.

FRANK N. KELLER, of Denver, has been appointed engineer inspector for PWA in Colorado, Utah, and Wyoming.

JOSELYN J. RICHARDSON, division engineer, Canadian National Railways, has retired and is to be succeeded by ALAN D. CUTHBERT.

A. R. WELLWOOD, head of the division of rates, costs and valuations, Federal Power Commission, will supervise, temporarily, the newly opened Atlanta office of the commission.

C. J. MCGAVIN has been appointed chief engineer, N. R. CAXSCALLA, administrative engineer, and C. H. BIDDELL, chief draftsman, of the Prairie Farms Reclamation Board of Saskatchewan, Canada.

C. M. COFF has been appointed manager in charge of construction for the Three Companies: J. A. Terteling & Sons; Haas, Dougherty & Jones; and Morrison-Knudsen Company, Inc.; contractors for the excavation of the 90-mile tri-county canal in Nebraska.

A. B. FIELDNER, chief engineer, experiment station division, United States Bureau of Mines, has been chosen as the new president of the American Society for Testing Materials. Dr. Fieldner has been with the Bureau of Mines since it was established in 1910.

WILLIAM B. POWELL, civil engineer, has been appointed traffic engineer for the city of Buffalo, N. Y., a new post in the municipal government. Buffalo is the first city in the state to create such a position. Mr. Powell has recently worked out traffic safety programs for Rhode Island and South Carolina, and is a member of the President's Committee for National Highway Traffic Safety.

CAPTAIN THOS. J. MAHER, for eight years in charge of the San Francisco office, U. S. Coast and Geodetic Survey, has been transferred to Manila, P. I., where he will be director of the Survey's activities in the Philippine Islands. During Captain Maher's stay at San Francisco he took a leading part in organizing the seismic investigations which have been a feature in the Survey's activities in California in recent years. COMMANDER RICHARD R. LUKENS, U. S. N., has been named to succeed Captain Maher at San Francisco.

BYRON BIRD has been appointed associate consultant of the National Resources Committee with headquarters at St. Louis, Mo.

JAMES S. LEWIS, JR., has been appointed assistant construction superintendent at Chickamauga Dam. Mr. Lewis was formerly in charge of foundation treatment at the Norris Dam.

ALEXANDER POTTER, sanitary engineer of New York City, was awarded the degree of Doctor of Engineering on June 9 by Lehigh University. Mr. Potter already holds the degree of C.E. from Lehigh.

LORENZ E. ORDELHEIDE has been appointed sanitary engineer of St. Louis County, Mo. For the past three years Mr. Ordelheide has been assistant state director of malaria control, supervising WPA projects.

WILLARD T. CHEVALIER, vice-president, McGraw-Hill Publishing Co., and publishing director, *Engineering News-Record*, received the degree of Doctor of Science from the Colorado School of Mines at its recent commencement exercises.

WILLIAM J. MAGUIRE, superintendent of buildings, Providence, R. I., has been confirmed by the United States Senate for the post of PWA director for Rhode Island, where he will have charge of an $8,000,000 construction program, now under way. He succeeds Eugene F. Kriegsman, acting state director since March.

C. B. HARVESON has been appointed engineer of maintenance of way of the eastern lines of the Baltimore & Ohio R.R. He succeeds P. Petri, recently advanced to chief engineer of maintenance of the system. Mr. Harveson has been with the Baltimore & Ohio Railroad since 1922. In 1927 he became division engineer of the east end of the Baltimore division and was transferred to a similar post on the west end of that division in 1933. Before 1922 Mr. Harveson was with the Reading Railroad.

P. PETRI, for the past ten years engineer, maintenance of ways, of the eastern lines of the Baltimore & Ohio Railroad, has been appointed chief engineer for maintenance of the entire system, succeeding the late Earl Stimson. Mr. Petri entered the Baltimore & Ohio's employ as an assistant engineer in 1899. He became assistant division engineer in 1906, and division engineer in 1907. During 1918 and 1919, Mr. Petri was special engineer in the office of the assistant to the federal manager at Baltimore. He has been in charge of maintenance of way on the eastern lines since 1926.

Obituary

FRANK MARCUS COOPER, retired civil engineer of Harrisburg, Pa., died June 16 at the age of 68. Prior to his retirement Mr. Cooper was connected with the McClintic-Marshall Co. as a designer.

A. E. LEGARE of Columbia, S. C., died June 21 at Columbia. Mr. Legare was state sanitary engineer with the South Carolina State Board of Health, and was

secretary of the South Carolina Society of Engineers.

ERNEST IFILL SHADBOLT, former director of railway construction for the government of India, died in London, June 17, at the age of 87.

FRED W. NEINHOLTZ, building contractor in St. Louis for the past 47 years, died June 13 at the age of 71.

ANDREW B. MAUZY, chief engineer of the Jersey City Water Bureau, died in Jersey City on June 19.

JAMES C. MEEM, consulting engineer with the Underpinning & Foundation Co., died on June 24 in New York City at the age of 71. Mr. Meem was a graduate of the Virginia Military Institute and was for many years associated with the Frederick L. Cranford Co. He was regarded as an authority on soil pressure systems, tunnel construction, and trenching.

GEORGE T. CLAXTON, builder and contractor of Buffalo, N. Y., died in that city on June 24 at the age of 71.

A. STANTON ZINN, formerly sanitary engineer for Los Angeles county, California, died at South Bend, Ind., on May 7. Mr. Zinn was honored by the late Theodore Roosevelt for his part in building the Panama Canal.

In the June 18 issue Mr. Zinn's name was incorrectly given as Ginn.

SAMUEL H. WEBSTER, for the past 29 years head of the civil engineering department at Rhode Island State College, Kingston, R. I., died in Providence on June 22. Mr. Webster was a graduate of Waynesburg College, Leland Stanford, and the University of Illinois. He taught at Washington State and Oklahoma State Universities before going to the Rhode Island State College.

CHARLES K. CADMAN died in San Francisco on June 28 at the age of 74. Mr. Cadman served for three years on the staff of General G. W. Goethals, who directed the Panama Canal construction. He was head of the staff of Chief Engineer B. J. Arnold during the building of the subway in Chicago. Other of his projects included the Colima line of the Mexican Railway, the Throckmorton dam of the San Francisco water supply system, and the Santa Fe Railway tunnel at Pinole.

CONSTRUCTION STATISTICS FOR THE WEEK

ENGINEERING construction contracts total $37,467,000 for a four-day week. (Early closing account July 4.) This total comprises private work, $4,503,000; public, $32,964,000 of which $25,260,000 is state and municipal and $7,704,000 federal. Corresponding values a year ago are: total, $19,429,000; private, $5,365,000; state and municipal, $12,191,000; federal, $1,873,000.

Streets and roads, sewerage and earthwork, irrigation, drainage and waterways show gains this week. The volume by classes of work is: streets and roads, $11,381,000; earthwork, irrigation, drainage, waterways, $6,973,000; sewerage, $3,805,000; industrial buildings, $1,375,000; commercial buildings, $2,060,000; public buildings, $3,700,000; bridges, $5,054,000; waterworks, $940,000; unclassified, $2,179,000.

The larger contracts for the week include: addition to plant, Climax Molybdenum Co., Climax, Colo., $350,000; high school, Cranford, N. J., $551,000; highways, Georgia, $1,086,000; Missouri, $1,655,00; Kansas, $790,000; Pennsylvania, $521,000; Mississippi, $1,132,000; Texas, $505,000; improving streets, relief labor, Norfolk, Va., $540,000; bridges, Pennsylvania, $439,000; Texas, $747,000 and $644,000; Louisiana and Texas, $564,000; bridge improvements in Erie County, state forces, Pennsylvania, $400,000; Vasquez-St. Louis Collection Conduit, Moffat Tunnel Project, Bd. Water Commissioners, Units 10 and 11, Colorado, $574,000; intercepting sewers, Buffalo Sewer Authority, divisions Ka, L, and M, Buffalo, N. Y., $2,626,000; north shore levees at Lake Okeechobee, U. S. Engineer, Jacksonville, Fla., $1,059,000; dredging Illinois Waterway, U. S. Engineer, Chicago, Ill., $630,000; dikes, revetments, etc., Decatur and Louisville Bend, Missouri River, U. S. Engineer, Omaha, Neb., $550,000; dikes and revetments, Nebraska and Iowa, $575,000; dredging Inland Waterway, U. S. Engineer, Philadelphia, Pa., $2,067,000.

New capital for the week includes $11,395,000 in state and municipal bond sales, $4,500,000 in new corporate issues, and $417,000 bonds sold by RFC.

CONTRACTS

(Thousands of Dollars)

	Weekly Average July 1935	Prev. 4 Weeks	Week July 2 1936
Federal Government	$3,826	$6,984	$7,704
State and Municipal	12,285	25,351	25,260
Total public	$16,111	$32,335	$32,964
Total private	5,607	13,644	4,503
Week's total	$21,718	$45,979	$37,467
Cumulative to date:			
1935..$676,700,000	1936..$1,158,842,000		

NEW PRODUCTIVE CAPITAL

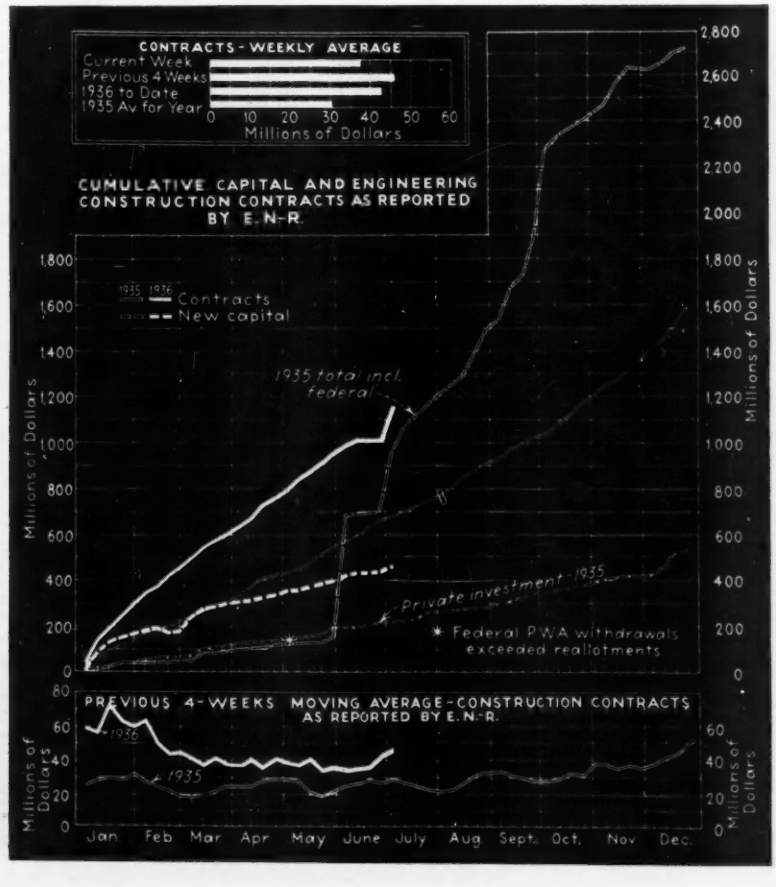
(Thousands of Dollars)

1936	Week July 2	Cumulative
State and municipal	$11,395	$285,650
PWA non-federal	....	32,190
RFC loans	471	12,479
Corporate issues	4,500	123,474
PWA loans, Private	....	3,270
Total Non-Federal	$16,366	$457,063
Federal	....	4,955
Total new capital	$16,366	$462,018
Cumulative to date:		
1935...$702,782,000	1936...$462,018,000	

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, including the special highway funds; PWA private loans, and allotments for federal construction, deficiency act funds.

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
July, 1936	202.60	97.38	June, 1936	196	86
June, 1936	204.60	98.35	May, 1936	149	65
July, 1935	195.18	93.82	June, 1935	122	54
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50
1933 (Av.)	170.18	81.80	1933 (Av.)	102	47



BUSINESS SIDE OF CONSTRUCTION

Construction Contracts Gain in 1936 June Awards Higher Than May

THE first six months of 1936 closed with private engineering construction registering a gain of 58 per cent over the same period last year and public a gain of 76 per cent while federal contracts show a drop of 15 per cent. State and municipal contracts show a rise of 113 per cent over 1935. In dollar value, total engineering construction for the first six months is $1,121,375,000 in 1936 compared with $657,271,000 in 1935; federal awards $116,268,000 compared with $136,944,000 in 1935; total public, $822,745,000 compared with $468,404,000 in 1935 and private awards, $298,630,000 compared with $188,867,000 in 1935.

Geographically, the national total is distributed as follows: New England, 70 per cent gain over the first six months of 1935; Middle Atlantic, 115 per cent gain; South, 28 per cent gain; Middle West, 41 per cent gain; West of Mississippi, 97 per cent gain; Far West, 56 per cent.

Commercial buildings show the greatest increase, 101 per cent ahead of 1935; public buildings, 94 per cent ahead; industrial buildings, 38 per cent ahead; and streets and roads, 85 per cent ahead. All other classifications show a rise with the exception of earthwork and waterways and unclassified construction.

June Awards

June awards show a gain of 30 per cent over the May volume. Both public and private construction were higher. The 1936 values for a 4-week month are, total, $183,917,000; public, $129,339,000; private, $54,578,000; federal, $27,394,000. The corresponding values for June, 1935, are, total, $110,161,000; private, $38,700,000; public, $71,461,000; federal, $26,816,000. By average per week June at $45,979,000 compares with May at 35,314,000 for total awards and $13,644,000 for private construction compared with $9,509,000 in May. Public awards at $32,335,000 compare with $25,805,000 in May.

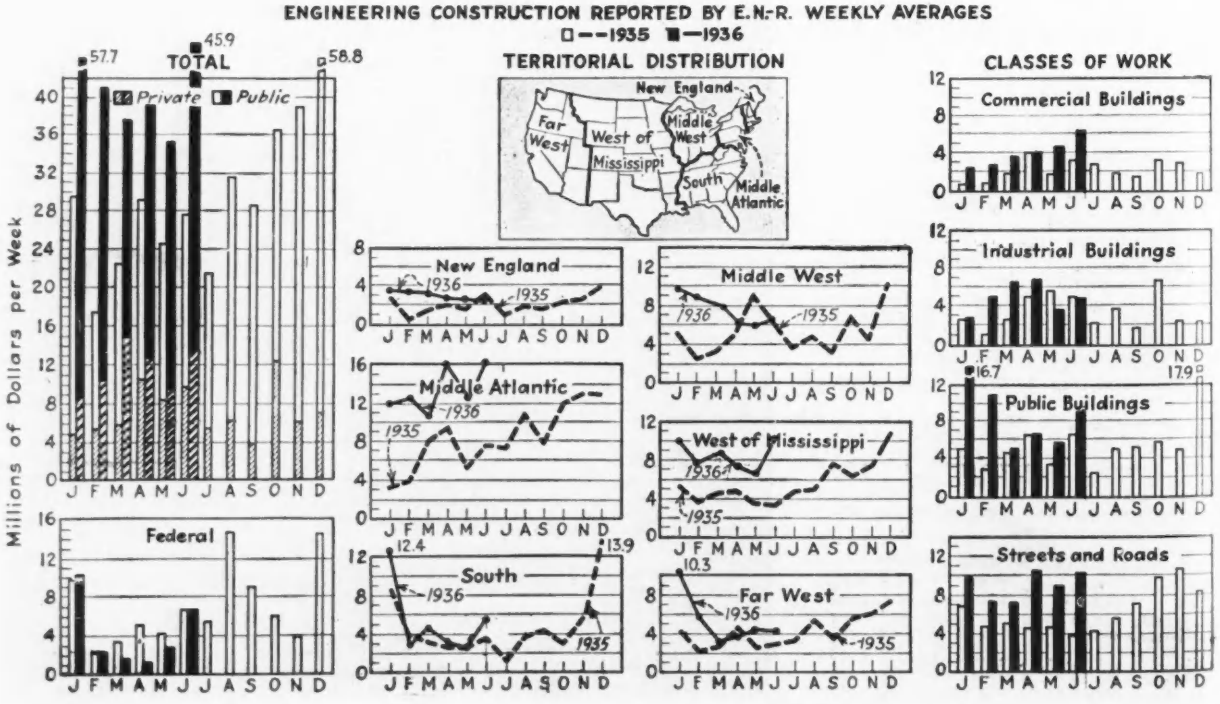
Highway construction shows an increase of 14 per cent over May, while public buildings were 68 per cent higher, commercial buildings 32 per cent higher and industrial buildings, 34 per cent higher than the May figure.

Territorially, the South shows the strongest rise, 53 per cent increase over May; 46 per cent in West of Mississippi; 25 per

ENGINEERING CONSTRUCTION CONTRACTS REPORTED IN JUNE, 1936

Four Weeks—Thousands of Dollars (000 Omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States June 1936	United States Six Months 1936	United States Six Months 1935	Canada June 1936
Public Works										
Waterworks	122	861	169	1,308	2,351	1,030	**5,841**	59,263	35,561	123
Sewerage	290	903	55	2,719	2,042	138	**6,147**	69,925	33,448	131
Bridges, public	720	3,216	1,096	2,873	5,335	991	**14,231**	85,154	34,652	86
Earthwork and waterways	3,977	1,132	708	306	3,121	4,250	**13,494**	77,457	86,342	276
Streets and roads	725	7,355	6,658	8,484	14,504	3,438	**41,164**	237,786	128,615	6,677
Buildings, public	3,750	21,297	4,166	2,172	5,810	2,231	**39,426**	239,136	123,416	750
Unclassified, public	91	7,800	423	216	147	359	**9,036**	54,024	26,370	71
Total public	9,675	42,564	13,275	18,078	33,310	12,437	**129,339**	822,745	468,404	8,114
Federal gov't (included in above classifications)	5,384	9,512	3,046	1,560	3,738	4,694	**27,934**	116,268	136,944	.....
Private										
Bridges, private	.....	51	.....	62	150	.....	**263**	4,200	7,856	.....
Buildings, industrial	1,291	3,556	7,877	5,110	595	960	**19,389**	125,609	91,166	2,461
Buildings, commercial	820	17,917	2,015	1,805	1,095	2,053	**25,705**	102,476	50,862	492
Unclassified, private	14	345	.....	1,428	6,111	1,323	**9,221**	66,345	38,983	25
Total private	2,125	21,869	9,892	8,405	7,951	4,336	**54,578**	298,630	188,867	2,978
June, 1936 (4 weeks)	**11,800**	**64,433**	**23,167**	**26,483**	**41,261**	**16,773**	**183,917**	.....	.....	**11,092**
May, 1936 (4 weeks)	10,652	51,447	11,123	22,881	27,852	17,302	**141,257**	.....	.....	2,091
June, 1935 (4 weeks)	12,234	31,903	14,782	24,556	14,719	11,967	**110,161**	.....	.....	10,722
Six months, 1936	78,721	347,407	141,063	194,840	220,513	138,831	.....	1,121,375	.....	44,450
Six months, 1935	46,375	161,909	109,986	137,905	112,078	89,018	.....	.....	657,271	33,751



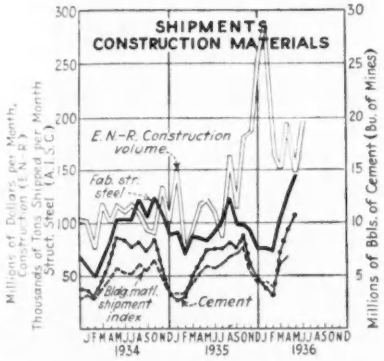
cent in Middle Atlantic; 13 per cent in Middle West. In New England and in the Far West the volume remains practically the same as in May.

New Capital

State and municipal bond sales in June totaled $35,052,000 compared with $61,122,000 in May, a drop of 42 per cent. Corporate security issues for the month totaled $15,161,000 compared with $21,579,000 in May.

Materials

Cement—The Portland cement industry in May, 1936, produced 10,985,000 barrels, shipped 11,121,000 barrels from the mills, and had in stock at the end of the month 20,435,000 barrels. Production and shipments of Portland cement in May, 1936, showed increases of 33.6 and 49.7 per cent,


SHIPMENTS
CONSTRUCTION MATERIALS
E.N.-R. Construction volume
Fab. str. steel
Bldg. matl. shipment index
Cement
Millions of Dollars per Month, Construction (E.N.-R.)
Thousands of Tons Shipped per Month Struct. Steel (A.I.S.C.)
Millions of Bbls. of Cement (Bu. of Mines)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1934
1935
1936

respectively, as compared with May, 1935. Portland cement stocks at mills were 7.1 per cent lower than a year ago, as reported by the Bureau of Mines.

The ratio of production to capacity for May was 48.9 compared with 36.1 the previous year and 39.2 the previous month.

Steel—The operating rate of steel companies having 98 per cent of the steel capacity of the industry and reporting to the American Institute of Steel Construction was 69.1 per cent for June, the same rate as for May. This rate compares with 38.6 for June, 1935.

May bookings for structural steel were 39 per cent larger than the bookings for April, and 141 per cent larger than for May, 1935, according to the records compiled by the American Institute of Steel Construction. The improved volume of bookings during May brought the total of business booked during the first five months of the year to 52.2 per cent of normal (normal being the yearly average for the period 1928-1931 inclusive). This was the best record of the industry since 1931. While the shipments during May were larger than for any month this year so far, they have not reached the volume of the new business booked.

Lumber—The lumber industry during the week ended June 20 stood at 69 per cent of the 1929 weekly average of production and 65 per cent of 1929 shipments, according to the National Lumber Manufacturers Association. For the tenth consecutive week, production exceeded new orders and for the seventh week, it exceeded shipments. During the week, 564 mills produced 253,147,000 ft., shipped 244,641,000 ft. and booked orders for 251,741,000 ft.

The index of shipments of construction materials, compiled by Advance Construction Program Unit, Space Control, rose to 75 for May compared with 59 a year ago and 65 last month.

Building Permits

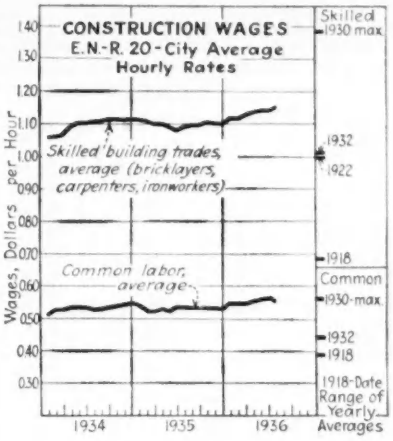
The dollar value of permits issued in 215 cities of the United States, according to Dun & Bradstreet, Inc., was $82,319,896 in May against $83,903,095 in April and $49,327,248 in May, 1935. The margin of increase over last year continues large, amounting to 66.9 per cent in May, as against a rise of 62.4 per cent in April.

Labor

Employment in the production of six major construction materials as reported by Advance Construction Programs Unit, Space Control, is 52.5 for May compared with 49.7 in April and 43.1 in May, 1935.

Reports received by the Bureau of Labor Statistics, U. S. Department of Labor, from 9,144 contractors engaged in private building construction in May showed gains of 14.8 per cent in employment and 20 per cent in payrolls over April. The increase in May, 1936, are more pronounced than the gains shown in May of any of the four preceding years for which information is available and indicate the added volume of building operations now under way. Employment in the private building construction industry in May, 1936, was 23.7 per cent above the level of May, 1935, and payrolls were 39.8 per cent higher than in the corresponding month of last year. The information furnished by reporting contractors relates to employees engaged in erecting, altering, and repairing private buildings and does not include projects financed by the Public Works Administration, Reconstruction Finance Corporation funds or regular appropriations of the federal, state, and local governments.

There were more than 3,150,000 workers



employed on the works program financed from the Emergency Relief Act of 1935 during the month ending May 15. This is a decrease of about 70,000 compared with the previous month. Of the number employed in May, 2,563,000 were working on projects operated by the Works Progress Administration.

The Public Works Administration construction program provided employment for more than 315,000 workers in May. This includes 145,000 employees working on projects financed from E.R.A. 1935 funds, who are also included under the Works Program. Employment on the Public Works Administration program showed an increase of 60,000 workers in May as compared with April.

There were approximately 26,000 additional workers employed on state construction work in May. During the month 181,000 employees were engaged in the construction and maintenance of roads financed wholly from state funds.

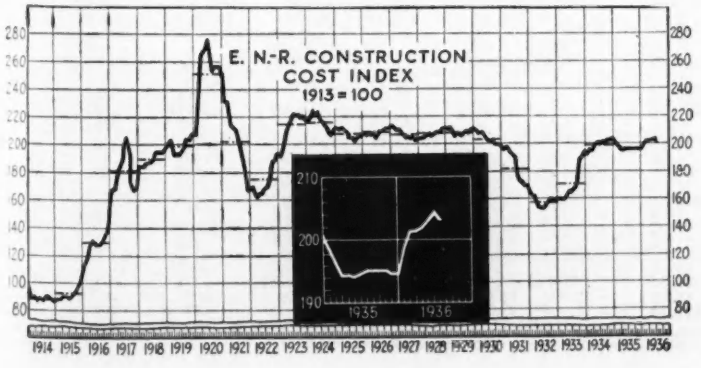
There was an increase of 20,000 in number of workers employed on construction projects financed from regular governmental appropriations during May.

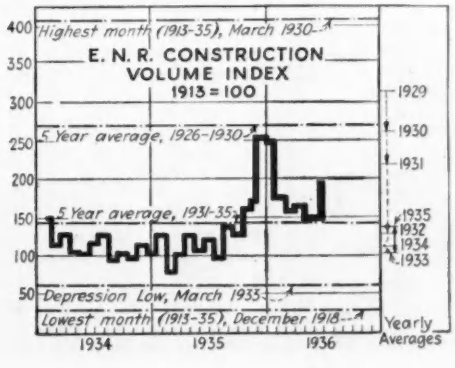
ENR Cost and Volume Index

THE *Engineering News-Record* Construction Cost Index is 202.60 for July. The decrease is due to a decrease in the common labor wage average.

The *ENR* Volume Index is 196 for June.

	INDEX NUMBER				
ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
July, 1936.	**202.60**	**97.38**	**June, 1936**	**196**	**86**
June, 1936	204.60	98.35	May, 1936	149	65
July, 1935	195.18	93.82	June, 1935	122	54
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50
1933 (Av.)	170.18	81.80	1933 (Av.)	102	47





CURRENT PRICES OF CONSTRUCTION MATERIALS

CEMENT, AGGREGATES AND READY-MIXED CONCRETE—F.O.B. CITY

	PORTLAND CEMENT (Per bbl., carload lots, including 40c. per bbl. for bags, cash discount not included)			SAND AND GRAVEL (Per ton, carload lots)			CRUSHED STONE (Per ton, carload lots)		CRUSHED SLAG (Per ton, carload lots, f.o.b. plant)		CONCRETE (Ready Mixed 1:2:4, 50c. or more, delivered)
	Cloth Bags*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	1½ in.	¾ in.	
Atlanta	$2.83	$2.58	$2.50	$1.60	$1.60	$1.55	$1.69	$1.92	$1.69	$1.69	$8.50
Baltimore	2.66	2.41	2.21	1.80‡	1.80‡	1.30‡	1.80‡	1.80‡	1.80	1.80	7.35
Birmingham	2.40	2.15	1.95	1.80	1.80	1.40	1.00	1.00	.90	1.15	5.45
Boston	2.42	2.12	1.92	1.40	1.40	.90	1.40	1.40	.....	.....	6.50
Chicago	2.60	2.35	2.20	1.50	1.50	1.80	1.32	1.32	1.00	1.00	.....
Cincinnati	2.50	2.25	2.05	1.20	1.20	1.30	1.80	1.80	.....	.....	6.70
Cleveland	2.41	2.16	.....	1.40	1.40	1.40	1.60	1.60	1.75	1.75	7.85
Dallas	2.45	2.20	2.00	1.55	1.55	1.30	1.95	2.05	.....	.....	7.00
Denver	3.09	2.84	.....	1.20	1.40	.90	.....	.....	.....	.....	.....
Detroit	2.25	2.00	1.80	1.25	1.25	1.10	1.50	1.75	1.35‡	1.45‡	5.95
Kansas City	2.51	2.26	2.06	1.85	1.85	1.25	1.85	1.85	.....	.....	7.65
Los Angeles	2.32	2.12	.....	1.20	1.20	.90	1.20	1.20	.....	.....	6.31
Minneapolis	2.90	.....	2.45	1.00p	1.00e	.25p	1.00p	1.00	.....	.....	6.75d
Montreal	.....	2.62	1.70	.85	.90	1.00	.85‡	1.20‡p	.....	.....	4.50i
New Orleans	2.47	2.22	2.00	1.50	1.50	1.25	.....	.....	.....	.....	8.25
New York	2.70‡	2.45‡	.....	1.20†k	1.20†k	.70†k	1.75†k	1.85†k	.....	.....	8.00
Philadelphia	2.68	2.43	2.23	1.45‡	1.55‡	1.15‡	2.60‡	2.75‡	1.05‡	1.00‡	8.00j
Pittsburgh	2.46	2.21	1.61	1.50‡	1.50‡	1.70‡	2.25‡	2.25‡	1.50	1.50	7.00
St. Louis	2.53	2.28	.....	1.55‡	1.40‡	1.25/1.40‡	.75p	.75p	.65/.95§	.50/.95§	6.95
San Francisco	2.72	2.52	2.20	1.35	1.35	1.35	1.50	1.50	.....	.....	7.53
Seattle	2.95	2.70	.....	1.00	1.00	1.00	1.44	1.44	.....	.....	6.75

*10c. allowed for each returnable bag. †Per cu. yd. ‡Delivered. §F.o.b. Granite City, Ill. aBarge lots alongside dock. pf.o.b. plant. t5 tons or more. wWithin 3-mi. from Pub Square. xton. d 5% discount for cash. D Discount 35c. 500 to 2000; 70c. 2000 to 5000; 95c. over 5000.

CURRENT MAXIMUM PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable

	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Alpena, Mich.	$1.50	$1.45	Ironton, Ohio	$1.50	$1.45	North Birmingham, Ala.	$1.75	$1.70
Buffington, Ind.	1.70	1.65	Iola, Kans.	1.70	1.65	Richard City, Tenn.	1.85	1.80
Crestmore, Calif.	1.72	.....	La Salle, Ill.	1.70	1.65	Saginaw, Mich.	1.50	1.45
Dallas, Tex. (Inc. 5c. tax)	1.80	1.75	Limedale, Ind.	1.70	1.65	Steelton, Minn.	1.80	1.75
Hannibal, Mo.	1.70	1.65	Mason City, Ia.	1.70	1.65	Universal, Pa.	1.65	1.60
Hudson, N. Y.	1.75	1.70	Norfolk, Va.	1.76	1.71	Waco, Tex. (Plus 5c. Tax in Texas)	1.75	1.70
Independence, Kans.	1.70	1.65	Northampton, Pa.	1.65	1.60	Wyandotte, Mich.	1.45	1.40

Cash Discounts, Cement, to Contractors: truck delivery, 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount, 10c. per bbl. for payment within 15 days of date of invoice.

STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

	STRUCTURAL CLAY TILE—PARTITION—SCORED (Per M. lots of 2,000 pieces or over, 3x12x12 in.)	(4x12x12 in.)	(8x12x12 in.)	STRUCTURAL CLAY TILE—LOAD BEARING—SCORED (Per M. lots of 2,000 pieces or over, 8x12x12 in.)	(10x12x12 in.)	(12x12x12 in.)	BRICK (Per M. in quantity, Common backing)	(Straight hard)	LIME (Per ton, in paper, Hydrated finishing)	(Common hydrated)	(carload lot, Pulverized or lump)
Atlanta	$71.10	$75.80	$142.10	$170.50	$199.00	$227.40	$12.25	$14.25	$18.50	$13.00	$13.00
Baltimore	91.00	98.00	183.00	219.00	315.00	390.00	13.00	17.00	20.00	14.00	25.00
Birmingham	78.75	84.00	157.50	189.00	201.25	242.00	15.00	19.00	3.00§	1.75§	2.25§e
Boston	79.90,i	85.20,i	159.75,i	181.05,i	237.30,i	271.20,	14.50	18.00	20.00	15.50	3.50e
Chicago	66.00	70.40	132.00	174.30	214.40	245.00	10.20	11.20	18.00	13.40	14.00
Cincinnati	55.00	58.70	110.00	124.10	164.20	187.70	17.50	17.50	15.97	12.48	.....
Cleveland	45.00	48.00	90.00	108.00	138.50	158.50	13.75	13.75	16.00k	14.00k	2.65k,e
Dallas	72.00	75.00	149.00	177.00	217.00	269.00	13.50	26.00	19.00	16.00	1.65p
Denver	78.50	88.00	141.50	166.50	196.00	225.00	11.50	15.00	30.00k	22.00k	22.50k
Detroit	71.85	76.65	143.70	230.00	280.00	325.00	12.50	13.50	18.00	15.00	15.25
Kansas City	72.50	75.50	92.00*	140.50	177.75	207.25	13.00	24.00	18.90	12.40	10.35
Los Angeles	77.50	94.25	134.00*	188.00	232.50	311.50	11.50	14.00	18.70	.....	19.70
Minneapolis	80.15s	85.50s	145.40s	167.75s	175.25s	243.70s	13.10	15.10x	25.50	21.00	23.00
Montreal	79.10s	90.40	169.50s	.....	212.40	136.60	20.75	31.00	15.00	10.00	7.00
New Orleans	69.10	69.10	129.50	155.40	203.40	251.80	14.00	.....	18.90	11.35	.....
New York	78.40	83.60	125.40*	193.30†	238.80†	295.60†	12.50	.....	20.00	15.50	20.00
Philadelphia	86.00	90.00	159.00	200.00	240.00	280.00	18.00	20.00	16.35	11.25	10.75
Pittsburgh	58.40c	62.30c	116.85c	165.00c	217.00c	250.00c	16.50	25.00	17.25	14.50	2.22p
St. Louis	62.00	65.00	120.00	180.00	234.00	280.00	15.00	18.00	22.00	16.00	2.25p
San Francisco	84.00	94.50	225.00	.....	.....	.....	15.00	18.00	.55§	.40§	2.05p
Seattle	84.00	95.00	180.00	198.00	.....	.....	15.50d	18.50	30.00	20.00	28.60p

*6x12x12 in. †F.o.b. Perth Amboy, N. J. ‡Per sack. §Per bbl., 200 lbs. pPer bbl. 180 lbs. ePer bbl. 280-lb. kLCL. dless $1 cash 15 days. elump. sSmooth. xSelected common. iCarload lots delivered to job.

ROAD SURFACING MATERIALS—F.O.B. CITY

	PAVING BRICK AND BLOCKS: Granite (per M. lots of 50,000, 4x4x8 in.)	Brick (per M., 3x4x8½ in., carload lots)	Wood (per sq. yd., 3½ in., 16-lb. treat.)	PAVING ASPHALT (Per ton, less than 80 penetration, Tank car)	(Drums)	ASPHALT BINDERS—FLUXES (Per gal., 80-300 penetration, Tank car)	(Drums)	CUTBACK ASPHALT (Per ton, Tank car)	(Drums)	ROAD OILS (Per gal., Tank car)	ASPHALT EMULSION (Per gal., Tank car)	(Drum)
Atlanta	$ 75.00	$35.00	$2.25	$17.43z	$ 2.62z	$0.0687z	$0.100z	$18.15z	$26.20z	$0.687z	$0.0875	$0.0875
Baltimore	108.00	44.00	2.75	17.00	22.00	.075	.10	.09†	.125†	.....	.....	.....
Birmingham	110.00	25.00	.....	19.00	24.00	.0878	.1128	.10†	.137†	.....	.06	.....
Boston	75.00	26.00	2.75	17.00	22.00	.07e	.095e	.09†e	.12†e	.07e	.095e	.125e
Chicago	125.00	42.00	1.985	16.00	20.00	15.00	19.00	.07	.11	.045	.09	.135
Cincinnati	115.00	37.00	.....	13.47	17.47	.12	.....	17.00	.....	.055	.08	.....
Cleveland	100.00‡	32.75	2.85	17.00	21.00	.07	.08	.075	.045†	.0525	.085	.095
Dallas	.....	30.00	.....	18.00	21.75	.065	.16	18.75	26.25	.055	.085	.11/.135
Detroit	.....	37.00	.....	16.80	21.00a	.....	.....	15.25	20.25	.055	.11	.15
Kansas City	.....	39.00	.....	18.50	23.50	17.50#	22.50#	.077†	.107†	.057	.11	.15
Los Angeles	.....	50.00	.....	10.34	14.50	10.34#	14.50#	10.34	.....	.042	.06	.12
Minneapolis	.....	.....	1.75l	18.20	24.70	.098	.098	21.85	34.65	.048	.....	.....
Montreal	70.00	60.00	3.62	14.00	19.66	.07	.093	19.00	26.50	.07	.135	.165
New Orleans	100.00	32.00	.....	15.00	18.75	.068	.095	.075†	.10†	.....	.0785	.11
New York	120.00§	65.00	2.75	17.00	22.00	.075	.10	.09†	.125†	.....	.075	.11
Philadelphia	110.00	45.00	2.25	13.50	18.00	.05	.08	.05†	.08†	.045	.08	.....
Pittsburgh	115.00	40.00	.....	19.00	24.00	.0775	.1125	.086†	.121†	.0675	.....	.....
St. Louis	115/120	35.00	.....	19.70	24.70	.08775	.1075	.0825†	.1125†	.045	.09	.12
San Francisco	.....	50.00	.....	12.00	18.00	12.00#	18.00#	12.50#	23.00#	.04	.0575	.117
Seattle	.....	35.00	.....	25.50	25.50	17.00#	23.00#	15.00	.....	.03	.19	.20

Note: Paving asphalt, tank car or boat, f.o.b. Maurer, N. J., per ton. Bermudez, $25.00; Trinidad, $21.00. *Per sq. yd. †Per gallon. ‡4½x6x5½ in. #Per ton. §4x5x9-in. Av. aMexican. zLocal reduction due to 20% reduction intra-state class freight rates, only Georgia affected. l 2½ in. 6 to 8-lb. treatment. e F.o.b. Everett.

CURRENT PRICES OF CONSTRUCTION MATERIALS

IRON AND STEEL PRODUCTS—BASE MILL PRICES

	STRUCT. SHAPES-PLATE	REINF. BARS ¼-in. billet,	RIVETS ¾-in. structural	WIRE NAILS Base	SHEET PILING Base	STEEL RAILS Per Gross Ton Standard	Light	Re-rolled	TRACK SUPPLIES Angle bars	Std. spikes	Tie plates	Track bolts
Birmingham	$1.95	$2.10	$3.00	$2.55		$36.375	$34.00	$35.00	$2.55	$2.60	$1.90	$3.60
Chicago	1.95	2.10	3.00		$2.25	36.375	35.00	34.00	2.55	2.60	1.90	3.60
Pittsburgh	1.80	2.05	2.90	2.10	2.15	36.375	35.00	34.00	2.55	2.60	1.90	3.60

IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

F.O.B. WAREHOUSE	STRUCTURAL SHAPES Per 100 lb., base price	REINFORCING BARS Per 100 lb., ¾ in., base price New billet	Rail steel	EXPANDED METAL LATH Per 100 sq.yd., carload lots Std. diamond mesh, 3.4 lb.	Std. ribbed 3.4 lb.	WELDED FABRIC REINFORCING Per 100 s.f., carload lots 4x16 in., No. 5 & 10 wires	4x12 in., No. 8 & 12 wires	6x6 in., No. 6 & 6 wires Per sq. yd.	SHEET PILING Per 100 lb. base price
Atlanta	$3.36	$2.34	$2.19	$21.00	$23.00	$1.53	$1.16	$0.1449	$2.70
Baltimore	3.00	2.75	2.60	24.00	26.00	1.41	1.08	.1332	2.45
Boston	3.54	2.923	1.962	21.00†	23.00†	1.46	1.12	.1449	2.57
Chicago	3.20	2.10	1.95	22.00	24.00	1.40	1.08	.1323	2.35
Cincinnati	3.40	3.25	3.25	25.01	29.50	1.39	1.07	.1287	.....
Cleveland	3.31	2.75	2.60	20.00	22.00	1.37	1.06	.1287	.....
Dallas	3.25	2.625	2.475	21.00	28.00	1.63	1.23	.1548	3.005
Denver	3.95	3.76	3.61	22.00	25.00	1.68	1.26	.1584	.....
Detroit	3.42	2.20	2.05	20.00†	22.00†	1.41	1.08	.1323	2.43
Kansas City	3.75	2.75	2.60	15.50	19.00	1.50	1.14	.1422	2.79
Los Angeles	2.35	2.325		23.00	27.50	1.68	1.26	.1584	2.65
Minneapolis	3.45	2.86	2.71	22.00	26.00	1.51	1.15	.1431	2.67½
Montreal	2.90	2.40	2.30	32.00	33.00	2.30	1.71	.238	....
New Orleans				21.00	24.00	1.54	1.17	.1458	
New York	3.37	2.50	2.35	19.50	21.50	1.44	1.11	.1359	2.50
Philadelphia	2.98	3.06	2.22	20.00	24.00	1.42	1.09	.1332	2.46
Pittsburgh	1.80‡	1.85‡	1.90‡	20.00‡	22.00‡	1.34	1.04	.1260	2.15
St. Louis	3.45	2.45	2.30	20.00	23.00	1.42	1.09	.1341	2.30
San Francisco	3.15	2.475	2.325	23.00	28.00	1.68	1.26	.1584	2.60
Seattle	3.55	2.50	.....	24.50	26.50	1.68	1.26	.1584	2.60

‡Base Mill Price. Note: Shapes, bars and piling subject to quantity discounts. §Mill Price plus freight to Minneapolis. †f.o.b. delivered.

PAINTING AND ROOFING SUPPLIES—F.O.B.

	RED LEAD Per 100 lb. in 500-lb. lots Dry	WHITE LEAD Per 100 lb. in 500-lb. lots# in oil	READY-MIXED PAINT Per gal., drums Graphite*	Aluminum†	Ferric Oxide‡	ROOFING SUPPLIES Carload lots, f.o.b. factory Rolls, slate surfaced, 85-90 lb., per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating, per gal.	Tar pitch, 350--lb. bbl., per ton
Atlanta	$7.75	$11.00	$1.60	$2.50	$1.40	$2.02	$1.81	$1.81	$.36	$25.60
Baltimore	7.00	10.50	1.45	2.25	1.70	2.03	3.00	3.00	.35	25.00
Birmingham	7.25	11.00	2.35	2.35	1.85	2.01	1.77	1.77	.36	22.00
Boston	7.00	10.50	1.85	2.70	.05x	1.75	3.15	3.15	.43	20.00
Chicago	7.00	10.50	1.35	.....	.....	2.43	2.24	2.24	.32	33.00
Cincinnati	7.00	10.50	1.45	2.50	1.40	2.40	2.39ᴷ	2.39ᴷ	.36	21.00
Cleveland	7.00	10.50	1.70	2.45	1.40	1.55	1.75ᴷ	1.75ᴷ	.23	19.00
Dallas	7.25	11.50	1.80	2.10	.....	2.35ᴷ	3.80	3.80	.14	35.00
Denver	7.50	11.25	2.55	.....	.....	2.25	3.55	3.55	.35	30.00
Detroit	7.00	10.50	1.65	2.30	1.40	2.55	2.80	2.55	.35	30.00
Kansas City	7.00	10.62½	1.65	2.65	1.10	1.78	3.10–3.20	3.10–3.20	.25	24.50
Los Angeles	7.25	10.75	1.60	2.25	2.30	2.00	1.50	.....	.45	.....
Minneapolis	7.00	10.62½	.....	.....	.....	1.73v	1.67ᴷv	1.67ᴷv	.29	23.80
Montreal	.....	8.20	1.85	3.50	1.85	1.90	2.44	1.88	.55	1.52§
New York	7.00	10.50	1.75	2.35	1.40	1.75	1.61ᴷ	1.61ᴷ	.232	22.00
Philadelphia	7.00	10.50	2.50	2.95	1.50	1.68	1.85ᴷ	1.48ᴷ	.37	22.00
Pittsburgh	7.00	10.50	1.05	1.95	.80	1.75	1.65ᴷ	1.65	.38	25.00
St. Louis	10.00	10.50	1.85	2.45	1.30	1.83ᴷ	2.57	2.57	.25	25.00
San Francisco	7.25	10.75	1.80	2.75	1.10–2.00	1.89	3.10	3.10	.38	26.00
Seattle	7.25	10.75	1.80	2.85	2.20	3.30	2.66	2.60	.60	30.00

*U. S. War Dept. Spec. 3-49A. †ASTM Spec. D266-31. ‡80% maximum ferric oxide. §Per 100 lb. ᴷPer roll, 65 lb. xPer lb. v Minneapolis & vicinity
Note: Red lead in oil 50c higher than white lead in oil. #Basis of quoting changed this month from list to 500-lb. lots.

MISCELLANEOUS ITEMS

	WINDOW GLASS Discounts from latest jobbers List, Sept. 15, 1928 Single or Double Thickness A quality	B quality	EXPLOSIVES Per lb. dynamite delivered 50-lb. cases Gelatin 40%	60%
Atlanta	85%	85%	$0.155	$0.17
Baltimore	88%	90%	.145	.16
Birmingham	88%	90%	.095	.11
Boston	88–10–5%	90–10–5%	.165	.185
Chicago	88%	89%	.135	.15
Cincinnati	89–10%	91–10%	.27	.29
Cleveland	85%	85%	.20	.2125
Dallas	87%	89%	.1350	.1500
Denver	88%	90%	.155	.17
Detroit	87–10%	89–10%	.225	.240
Kansas City	86–10%	87–10%	.35	.15
Los Angeles	90%*	90–40%	.1725†	.1925†
Minneapolis	87%	88%	.145	.16
Montreal	60–30%	70–5%	.1825	.1950
New Orleans	88%	90%	.215	.23
New York	89%	90%	.215	.23
Philadelphia	88%	90%	.1550	.17
Pittsburgh	88%	88%	.11	.125
St. Louis	89%	89%	.115	.13
San Francisco	80%	85%	.1575	.1775
Seattle	90–10%	90–20%	.1425	.1575

*Disc. from list Aug. 1, 1929. †F.o.b. Arsenal. ‡Double thickness A & B.

CHEMICALS

Water, sewage treatment, road work, f.o.b. carlots, New York.

Bleaching powder, in drums, F.o.b. works, per 100 lb.	$2.00
Calcium chloride, 77-80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, f.o.b. works, freight equalized with points of competition, per ton	22.00–35.00
Chlorine cylinders, per lb. delivered	.055
Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb.	1.35
Soda ash, 58%, in paper bags, per 100 lb. dense	1.25
Sulphate of aluminum, commercial, in 100 lb. bags per ton	27.00
Sulphate of copper, in bbl., per 100 lb.	4.00–4.25

PILES

Prices per linear foot, pine, with bark on, f.o.b. New York; delivered from barge 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Short Leaf Barge	Short Leaf Rail	Long Leaf Barge	Long Leaf Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.12	$0.165	$0.13	$0.16
12 in.—2 ft. from butt.	6 in.	50 to 59 ft.	.16	.21	.15	.20
12 in.—2 ft. from butt.	6 in.	60 to 69 ft.	.17	.225	.16	.21½
14 in.—2 ft. from butt.	6 in.	50 to 69 ft.	.195	.235	.20½	.24½
14 in.—2 ft. from butt.	6 in.	70 to 79 ft.	.2125	.245	.24½	.30½
14 in.—2 ft. from butt.	5 in.	80 to 85 ft.	.275	.385	.....	.....
14 in.—2 ft. from butt.	5 in.	85 to 89 ft.	.315	.452	.....	.....

RAILWAY TIES Prices f.o.b., per tie, for carload lots:		6 In. x 8 In. by 8 Ft.	7 In. x 9 In. by 8½ Ft.
Boston	Oak, untreated	$1.10	$1.60
	Pine, untreated	1.25	1.70
	Pine, creosoted	1.65	2.30
New York	Long-leaf sap pine, untreated	.80	1.00
	Mixed oak, untreated	1.00	1.20
	White oak, untreated	.85	1.35
Birmingham	Red oak, creosoted	1.50	1.70
	Southern pine, untreated *6x8x8'6'	.55*	.70
	Southern pine, creosoted	1.10*	1.30
Chicago	White oak, untreated	1.15	1.40
	Oak, empty cell, creosoted	1.50	1.88
	Oak, zinc treated	1.40	1.70
	Southern pine, creosoted	1.35	1.78
Los Angeles	Fir, untreated	.50	.72
	Fir, creosoted	1.67	2.40
Philadelphia	Red oak, untreated	1.00	.....
	Red oak, creosoted	.....	2.10
St. Louis	White oak, untreated	1.13	1.45
	Red oak, untreated	1.10	1.40
	Red oak, creosoted	1.50	1.95
San Francisco	Sap Pine or cypress, untreated	.95	1.30
	Douglas fir, green, untreated	.45	.63
	Douglas fir, empty cell, creosoted	1.14	1.56
Montreal	Birch or maple, untreated	1.00	1.10
	Birch or maple, creosoted	1.25	1.55

CURRENT PRICES OF CONSTRUCTION MATERIALS

PLUMBING, HEATING, WATER, SEWER AND DRAIN PIPE

	C. I. PIPE	VITRIFIED SEWER PIPE				CLAY DRAIN TILE		CONCRETE SEWER PIPE		WROUGHT STEEL PIPE			
										Full standard weight, #			
	Per net ton, f.o.b. 6 in. to 24 in.*	Per foot, delivered, ASTM C 13-35 8 in., s.s.	12 in., s.s.	24 in., d.s.	30 in., d.s.	Per 1,000 ft., carload lots, f.o.b. 6 in.	8 in.	Per ft., delivered; ASTM C 14-35 12 in.	24 in.	1 to 3 in., Butt Weld Black	Galv.	3½ to 6 in., Lap Weld Black	Galv.
										%	%	%	%
Atlanta	$43.00	$0.225dl	$0.405dl	$1.4625l	$4.50l	$80.00	$128.00	$0.45	$1.625	49.5	40.5	47	37
Baltimore	46.50	.28	.54	2.38	7.18	110.00	170.00	.40	1.60				
Birmingham	39.80	.25	.45	1.625	4.66	85.00	220.00	.40	1.60	69.5	61.5	67	58
Boston	46.50	.274	.432	1.98	5.845	99.00	153.00	.42	2.35				
Chicago	47.50	.245	.4725	2.025	4.60	60.00	120.00	.36	1.42	58.75	48.75	55.625	45
Cincinnati	46.00	.189	.3645	1.62	5.53c	69.00	108.00	.40	1.40	58.75	48.75	55.625	45.00
Cleveland	47.50	.168	.324	1.44	4.1225	42.50	88.50	.32	1.58	61	51	57.9	47.25
Dallas	51.00	.35	.67	2.70	.....	165.00	260.00	.46	1.57	64	55	64	55
Denver	59.00	.27‡	.47‡	1.98‡	.....	105.00	180.00	.....	.....	53	40	47	36
Detroit	47.50	.203	.3915	1.71	5.2375	82.00	136.00	.55	1.20	59.3	49.3	56.1	45
Kansas City	49.00	.30	.54	2.16	5.00	120.00	140.00	.49	1.50	55	45	51.5	41
Los Angeles	47.50	.2825‡	.508‡	2.03‡	5.535‡	115.50	192.50	1.00	2.00	62.1	54.1	59.6	51.1
Minneapolis	49.50	.24‡	.432‡	1.728‡	4.60‡	.....	.....	.65	1.65	.....	.....	.....	.....
Montreal	50.00	.33‡	.59‡	2.04‡	.....	82.00	134.00	.51	2.04	.....	.....	.....	.....
New Orleans	45.00	.23	.41	1.60	.....	67.00	.....	.95	1.65	.....	.....	.....	.....
New York	46.00	.28	.55	2.35	6.35	.....	.....	.55	2.00	57.50*	47.50*	54.375*	43.75*
Philadelphia	43.00	.336	.648	2.835	8.68	175.00	210.00	.54	1.80	52.37*	41.35*	53.39*	42.57*
Pittsburgh	49.00	.182‡	.351‡	1.62‡	4.92‡	69.00	108.00	.75c	1.75	69.5	61.5	67	58.5
St. Louis	46.00	.258	.459	1.83	3.96	85.00	170.00	.80	2.00	57.125	47.125	54	43.375
San Francisco	47.00	.29L	.522L	2.088L	5.67L	103.50	172.50	.45	2.20	53.69	47	50	39
Seattle	48.50	.4225	.63†	3.06†	7.55†	85.00	200.00†	.50†	1.80	65.80	57.25	66.75	56.30

*b. & s. class B and heavier, C/L lots, 200 tons and over. Burlington, N. J. (base) $43.00. Gas pipe and class A, $3 per ton additional. 4-in., $3 per ton additional. 30 in. and larger usually $2 per ton less.

#Discounts from standard list for delivery from warehouse, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ¼ in., 8½c; ⅜ in. 11½c.; 1 in., 17c.; 2 in., 37c.; 2½ in., 58½c.; 3 in., 76½c.; 4 in., $1.09; 6 in., $1.92.

‡f.o.b. †Less 30% in C/L Lots. c Concrete Culvert pipe reinforced. dDouble strength. lList to dealers. L list. tSales & municipal taxes extra

LUMBER AND TIMBER—PER M FT. B.M., CARLOAD LOTS F.O.B.

		SHORT LEAF YELLOW PINE AND DOUGLAS FIR—All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. All Fir planks No. 2 common; Fir timber is No. 1 common. Lengths up to 20 ft.								LONG LEAF Y. P. Merchantable grade up to 20 ft.	
		1x6,s	1x8,s	2x4,s	2x6,s	2x8,s	2x10,s	3x12,R	6x12,R	12x12,R	2x12,R	12x12,R
Atlanta	Southern Pine	$16.50	$16.50	$16.50	$18.50	$18.50	$20.00	$24.00	.....	.....	$38.50	$38.50
Baltimore	Southern Pine	23.50	24.50	27.50	26.50	27.00	29.00	37.50			55.00	57.00
	Douglas Fir	29.50	29.50	28.50	29.50	28.50	28.50	30.50	$29.00	$29.00	.....	.....
Birmingham	Southern Pine	21.00	21.00	22.00	20.00	21.00	23.00	30.00	30.00	28.00	.....	.....
	Long Leaf	22.00	22.00	25.00	24.00	25.00	28.00	45.00	.....	.....	45.00	45.00
Boston	Roofers N.C. Pine	28.00	28.00	33.00†	35.00†	49.00†	63.00†	73.00†	.....	.....	73.00	73.00
	Douglas Fir	27.00	27.00	31.00	33.00	35.00	37.00	40.00	40.00	41.00	.....	.....
Chicago	Southern Pine	29.00	29.50	33.50	32.50	32.50	35.50	45.50	.....	.....	54.50	54.50
Cincinnati	Southern Pine	25.50	25.50	26.50	26.00	27.00	29.00	43.00	.....	.....	45.50	55.50
	Douglas Fir							43.75	43.75	43.75		
Cleveland	Southern Pine	30.00	32.00	38.00	32.00	36.00	38.00	49.00	44.00f	46.00f	52.00	64.00§
Dallas	Southern Pine	28.35	30.60	31.50	29.80	30.15	30.15	50.00	82.50	66.50	42.75	67.95
Denver	Douglas Fir	42.00	42.00*n	43.00*	43.00*	43.00*	47.00*	52.00*	56.00*	61.50	.....	.....
Detroit	Southern Pine	26.50	26.50	26.50	26.50	27.50	30.00	37.00	.....	.....	31.00	43.50
	Douglas Fir							41.50	41.50	41.50	.....	.....
Kansas City	Southern Pine	25.50	27.50	25.50	25.50	26.50	28.00	37.00	.....	.....	55.00	62.50
	Douglas Fir	28.50	29.50	30.00	27.50	28.00	30.00	35.00	37.00	37.00	.....	.....
Los Angeles	Douglas Fir	31.00y	31.00y	31.00y	31.00y	31.00y	31.00y	38.00y	48.00y	41.00y	.....	.....
Minneapolis,c	Western Pine	45.00*	51.50*	50.00*	41.00*	41.00*	42.00*	59.50*x	.....	.....	58.00*h	.....
	Douglas Fir	42.00*	42.00*	43.00*	43.00*	43.00*	43.00*	55.00*	59.50*	59.50*	.....	.....
Montreal	Spruce	31.00	32.00	28.00	27.00	30.50	39.25	41.00	.....	.....	.....	.....
	Douglas Fir	47.50	53.00	42.50	44.00	44.00	45.75	52.00	52.00	52.00	43.25	.....
New Orleans	Southern Pine	23.50	25.50	28.00	25.00	27.00	25.50	38.00	.....	.....	44.00	54.00
	Douglas Fir	28.50	30.00	33.00	29.00	32.00	33.50	37.00	.....	.....	.....	.....
New York	Southern Pine	33.00*	34.00*	33.00*	34.00*	34.00*	38.00*	45.00*	.....	.....	70.00*	70.00*
	Douglas Fir			37.00*	37.00*	35.00*	38.00*	40.00*	43.00*	43.00*		
Philadelphia	Southern Pine	30.00	31.00	32.00	32.00	33.00	34.00	36.00	.....	.....	36.00	42.00
	Douglas Fir	45.00	45.00	45.00	45.00	45.00	45.00	45.00	42.00	42.00	.....	.....
Pittsburgh	Southern Pine	30.50	31.90	37.65	33.75	36.52	37.50	47.75	.....	.....	57.50	57.50
	Douglas Fir	38.52	39.70	39.70	38.55	39.10	39.38	53.25	53.25	53.25	.....	.....
St Louis	Southern Pine	29.50*x	30.50*x	31.00*x	30.00*x	31.00*x	32.00*x	46.00*x	.....	.....	.....	.....
	Douglas Fir								56.00*x	56.00*x	72.00	71.00
San Francisco	Douglas Fir	20.50f	20.50f	21.00f	21.00f	21.50f	22.50f	22.00f	25.00f	25.00f	.....	.....
Seattle	Douglas Fir	15.50	15.50	15.50	14.50	14.50	14.50	21.00	20.00	20.00	.....	.....

*Delivered. †Spruce. ‡Long-leafed Y.P. §Norway Pine. nNorthern Pine. tAt ship's tackle. yYard prices. d10% Disc. taken off. x5M ft. or less #S4S. RRgh. cContractors in Minneapolis and St. Paul get 15% disc. from list. f Douglas Fir.

CURRENT BUILDING AND CONSTRUCTION WAGE RATES PER HOUR

	Bricklayers	Carpenters	Structural Iron Workers	Hoisting Engineers	Plasterers	Common Labor—Building	Common Labor—Heavy Const.
Atlanta	$0.70/1.125	$0.40/.90	$0.60/1.25	$0.75/1.50	$0.60/1.00	$0.30/.40	$0.30/.40
Baltimore	1.25	1.10	1.37½	1.25	1.25	.45	.45
Birmingham	1.00	.60/1.00	1.00	1.125	1.00	.30/.40†	.30/.40†
Boston	1.30	.70/1.175	1.20	.90/1.425	1.375	.50/.625	.50/.70
Cincinnati	.80/1.375	.65/1.20	1.25	1.00/1.25	.80/1.375	.45	.45
Chicago	1.50	1.50	1.50	1.50	1.50	.95	.95
Cleveland	1.375	1.25	1.25	1.25	1.375	.82	.82
Dallas	.50/1.00	.50/1.00	.50/1.00	.50/1.00	.50/1.00	.25/.40	.25/.40
Denver	1.10	1.10	1.10			.625	
Detroit	1.25	.90/1.00	1.125/1.25	1.09/1.25	1.25	.50/.75	.50/.75
Kansas City	1.325	1.125	1.25	1.25	1.325	.70	.45/.50
Los Angeles	1.10	1.10	1.125	1.125	1.25	.50	.60
Minneapolis	1.00/1.25	1.00/1.10	1.00/1.25	.85/1.25	1.00/1.25	.50/.675	.50/.675
New Orleans	1.00	.75	1.00	1.00	1.25	.30/.40	.30/.40
New York	1.50	1.40	1.475/1.65	1.50/1.5625	1.50	.82½	.50/.80
Philadelphia	.35/1.50	.65/1.10	.70/1.375	.90/1.00	1.10/1.37	.35/50	.40/.50
Pittsburgh	1.50	1.25	1.375	1.00	1.50	.70	.50
St. Louis	1.50	1.25	1.47	1.35/1.47	1.50	.78¾	.35/.78¾
San Francisco	1.50*	1.125	1.37½	1.12½	1.25*	.62½	.60
Seattle	1.00	1.00	1.25	1.25	1.25	.60	.60
Montreal	.70	.60	.80	.55	.70	.35	.40

Skilled Avg: (Bricklayers, Carpenters, Ironworkers) $1.150 Common Avg. $0.554 *6-hr. Day . † PWA.